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A. F. DEAN

Joint Manager, Western Department, Springfield Fire and Marine Insurance Company of Massachusetts. Author of "Interest and Equation Exponents," "The Rationale of Fire Rates," "Fire Rating as a Science," "The Analytic System for the Measurement of Relative Fire Hazard," "Standardization in Fire Insurance," etc

Cyclopedia
of
Fire Prevention and Insurance

A General Reference Work

ON FIRE AND FIRE LOSSES, FIREPROOF CONSTRUCTION, BUILDING INSPECTION, INSPECTORS' REPORTS, PRIVATE AND PUBLIC FIRE PROTECTION, COMMON AND SPECIAL HAZARDS, CHEMISTRY OF COMBUSTION, UNDERWRITERS' REQUIREMENTS, FIRE INSURANCE LAW, THE STANDARD POLICY, RATING, UNDERWRITING, BROKERAGE, SETTLEMENT OF LOSSES, ETC.

Prepared by

ARCHITECTS, ENGINEERS, UNDERWRITERS, AND PRACTICAL INSURANCE MEN

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THE following list of books on the subjects of Fire Prevention, Fireproof Construction, and Fire Insurance is not intended to be complete, but represents the best book literature in the field. Unfortunately, on account of lack of space, the many short pamphlets, addresses, and reprints from periodicals, containing a wealth of authoritative information, cannot be included. For these the reader is referred to the annuals and quarterlies of the various fire and insurance organizations and to the libraries.

Regarding annual and quarterly publications, it should be mentioned that annual volumes are published by the Fire Underwriters' Association of the Pacific, the Fire Insurance Society of San Francisco, the Fire Underwriters' Association of the Northwest, the Fire Insurance Society of Philadelphia, and the Insurance Institute of Hartford, while the Insurance Library Association of Boston publishes a quarterly bulletin containing the best index to insurance literature printed, the Fire Insurance Society of Chicago publishes a bulletin during certain months of the year, and the Insurance Society of New York publishes occasional bulletins. In England the Chartered Institute, formerly the Insurance Institute of Great Britain and Ireland, publishes, through C. R. Layton, London, England, an annual volume called The Journal. Along fire prevention lines two important series of publications should be mentioned, viz, the Annual Report and supplemental pamphlets of the National Board of Underwriters, and the annual and quarterly of the National Fire Protection Association, 87 Milk Street, Boston.

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Foreword

ABOUT two hundred and fifty years ago a man named Nicholas Barbon, following the marine practice of many years' standing, conceived the idea of broadening the risk to include fire in buildings or their contents. To each property owner who desired it, he guaranteed reimbursement up to a certain amount in case of loss, accepting in exchange for the responsibility of this risk an annual payment of a certain small amount called the premium. This was the beginning of the fire insurance business. Today, by the application of the law of averages and other scientific principles, what was at first a mere gamble has become a real co-operative business arrangement by which a host of owners pay yearly a small but carefully calculated sum to the insurance companies in order that the certain number of owners who are bound to be visited by fire during the year may be reimbursed for their losses. The insurance business has grown amazingly, until now it represents millions upon millions of capital, controls a vast army of employes, and covers almost every conceivable form of risk.

¶ And yet it is evident that a fire insurance policy does not represent the last word on the subject of protection. At best it is only financial protection and can be of no help in preventing the building from catching fire or from burning up. The payment of the loss by the insurance company may enable the owner to rebuild as good as new, but the useful material which has been reduced to impotent ashes can never be restored. Every fire, then, is a waste of the world's energy, and the yearly total of fire losses reaches such a staggering sum, particularly in this country, that a continuance of such annual sacrifices would seem to mean the possibility of our ultimate financial ruin. The principle of "conservation of the world's resources" demands a more rational method of procedure, namely, the construction of buildings of materials that *cannot* burn. Notwithstanding this most obvious conclusion, it is within the memory of many a man of today—and not the "oldest inhabitant" either—that the first real steps were taken to make use of methods and materials in building construction which would safeguard the building against this terrible destroyer.

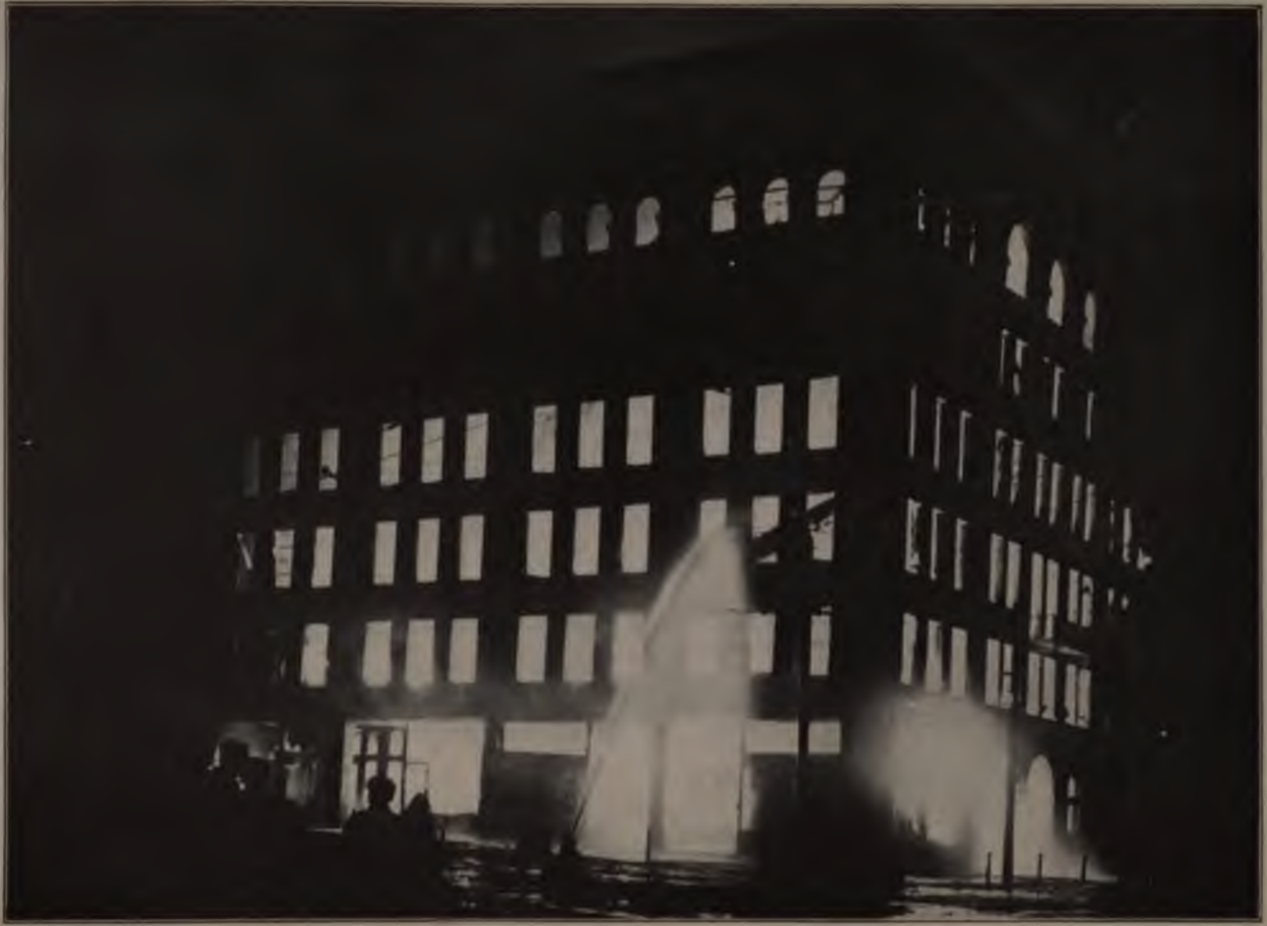
¶ Strange as it may seem, it took years of strenuous effort on the part of the believers in this principle of fire *prevention* before the movement could gain sufficient headway to become a potential force in the constructive activity of this country. The insurance policy—the easy road to financial reimbursement —was too alluring. Our forests seemed inexhaustible. Lumber was cheap and easily obtained, while steel and tile, concrete, and other fireproof materials were too expensive to be considered. In fact, the world had to suffer several serious conflagrations and in the end the owner, the architect, and the contractor had to be *compelled* by proper municipal legislation to build according to fire protective specifications before much progress could be made.

¶ The effect of this restrictive legislation is shown in its most complete form in Europe, where the broader area of the congested districts and the scarcity of lumber have forced the problem to its natural solution much earlier than in this country. The wonderfully effective "neighboring risk" idea, by which each owner is made liable for damage to his neighbor's property through fires due to his own carelessness or to the neglect of proper preventive methods, has also helped to stimulate the rapid adoption of the protective measures, resulting in fire losses per capita in different parts of Europe which are from six to twenty times lower than the figure for this country, and this, too, in the face of a much denser population.

¶ However, the cause of fire prevention and the appreciation of fireproof construction has progressed very rapidly in the United States during the last few years. The establishment of Boards of Underwriters, the development of Underwriters' Laboratories, where fire preventive appliances may be tested and certified to, the good work of the National Fire Protection Association and of the New England Factory Mutuals, and the earnest co-operation of the insurance companies with these seemingly antagonistic organizations, all show that we are rapidly approaching a period when fireproofing will be the rule instead of the exception, and when our present enormous annual fire losses will be reduced to a reasonable amount.

¶ It is with the idea of furthering this great cause of Fire Prevention, and of bringing to the attention of the general public the true function of Fire Insurance, its relation to Fire Prevention, and the methods which are used, that this work has been published. The literature on the subject, particularly along non-technical lines, has been very meager and it is hoped that this Cyclopedia will satisfy a long-felt want.

¶ The appreciation of the publishers is here expressed to the authors and collaborators—engineers, architects, underwriters, practical insurance men of wide experience, and teachers of recognized ability—for their counsel and guidance in the preparation of this work.



AN UNUSUAL PICTURE OF A NIGHT FIRE AT DOVER, NEW HAMPSHIRE
This Picture Was Taken by the Light of the Fire a Few Minutes Before the Walls Fell

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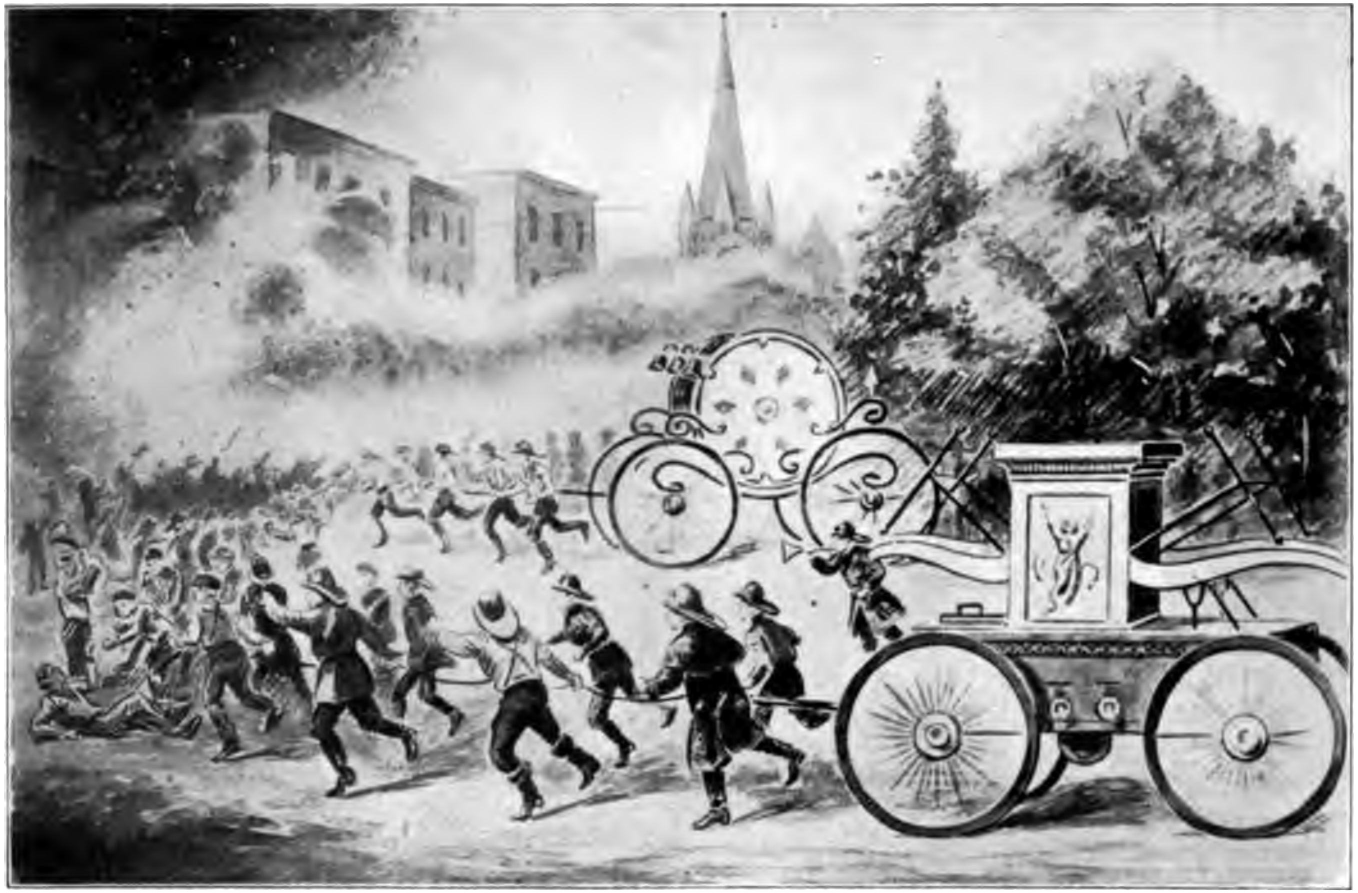

RIVAL FIRE COMPANIES RACING TO A FIRE IN 1845

CHEMISTRY OF COMBUSTION

INTRODUCTORY CHEMISTRY

CONSTITUTION OF MATTER

Whatever has weight is known as matter. There are a great many kinds of matter; and different kinds of matter are known as substances. Thus air, water, wood, coal, iron, and rocks are all substances. Matter can neither be created nor destroyed, but it is capable of undergoing many changes. For example, when water is heated sufficiently, it changes from a liquid to a vapor known as steam; iron when strongly heated melts, that is, changes from a solid to a liquid; again, when iron is allowed to remain in moist air it soon begins to change to a reddish-brown substance known as rust.

Physical and Chemical Changes. The change which iron undergoes when it is melted is of a different order from the change which it undergoes when exposed to moist air. In the former case the change is temporary, and the iron remains iron; when allowed to cool it again becomes solid. On the other hand when iron is exposed to moist air, it undergoes a permanent change, being converted into a substance essentially different from iron. Changes in which the composition of a substance is changed are called chemical changes, while changes which do not affect the composition of substances are called physical changes. Thus, when water is changed from ice to a liquid, or from a liquid to steam, the change which it undergoes is physical; in both cases it obviously undergoes a change, but still remains water. It may be heated and cooled again and again, without undergoing any permanent change, or change in composition. However, when a current of electricity is passed through water it undergoes a chemical change, the water being broken down into two gaseous substances, known as hydrogen and oxygen; these two gases have properties different from those of water, and when left to themselves they do not again become water.

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Another example of a chemical change is afforded by a burning match; when the match burns it evidently undergoes a permanent change as some of the solid constituents are changed into gaseous substances which will not burn, but are endowed with properties different from those of the original substance. All substances undergo changes in composition when they burn.

It is thus seen that the changes which various kinds of matter are capable of undergoing are divided into two general classes, namely, chemical and physical.

Chemistry is the science which treats of the chemical changes which matter is capable of undergoing, while *physics* is the science which treats of the physical changes of matter. These two classes of changes in matter are, however, so closely related that they cannot be studied independently; the two sciences, chemistry and physics, are, therefore, strictly speaking, inseparable. Chemical changes are always accompanied by physical changes; and physical changes very often serve to show that a chemical change has taken place or is in progress. A certain class of chemical changes which matter undergoes, and which is accompanied by the evolution of heat and light (fires), forms the principal subject matter of this book. As combustion is the term applied to this class of changes, it is obvious that the chemistry of combustion involves a study of both chemical and physical changes; and in order to study it intelligently it is necessary to have a certain amount of knowledge of general chemistry, particularly the meanings of many indispensable technical terms used by the chemist and physicist to denote certain general truths which hold good for all kinds of chemical action.

Elements. As already stated water may be broken down or changed chemically into two gases, hydrogen and oxygen, and this change or decomposition may be accomplished in several ways. It is also found that when these two constituent gases are brought together under the proper conditions they can be caused to unite and form water. No matter by what means water is decomposed, or how many times it is decomposed and again formed by causing hydrogen and oxygen to unite, the two and only two substances found to compose it are hydrogen and oxygen. These two substances cannot by any means now known be broken down or decom-

TABLE I

Names, Symbols, Atomic and Molecular Weights, and Physical Condition at Ordinary Temperatures of the More Important Elements

Name	Symbol	Approximate Atomic Weight	More Exact Atomic Weight	Approximate Molecular Weight	Physical Condition at Ordinary Temperature
Aluminum	Al	27	27.1		Solid
Antimony	Sb	120	120.2		Solid
Arsenic	As	75	75.0	300	Solid
Barium	Ba	137	137.4		Solid
Bismuth	Bi	208.5	208.5		Solid
Boron	B	11	11.0		Solid
Bromine	Br	80	79.96	160	Liquid
Calcium	Ca	40	40.1		Solid
Carbon	C	12	12.0		Solid
Chlorine	Cl	35.5	35.45	71	Gas
Chromium	Cr	52	52.1		Solid
Cobalt	Co	59	59.0		Solid
Copper	Cu	63	63.6		Solid
Fluorine	F	19	19.0		Gas
Gold	Au	197	197.2		Solid
Hydrogen	H	1	1.008	2	Gas
Iodine	I	127	126.97	254	Solid
Iridium	Ir	193	193.0		Solid
Iron	Fe	56	55.9		Solid
Lead	Pb	207	206.9		Solid
Lithium	Li	7	7.03		Solid
Magnesium	Mg	24	24.36		Solid
Manganese	Mn	55	55.0		Solid
Mercury	Hg	200	200.0	200	Liquid
Nickel	Ni	59	58.7		Solid
Nitrogen	N	14	14.04	28	Gas
Oxygen	O	16	16.0	32	Gas
Phosphorus	P	31	31.0	124	Solid
Platinum	Pt	195	194.8		Solid
Potassium	K	39	39.15		Solid
Silicon	Si	28	28.4		Solid
Silver	Ag	108	107.93		Solid
Sodium	Na	23	23.05		Solid
Strontium	Sr	87	87.6		Solid
Sulphur	S	32	32.06	36	Solid
Tantalum	Ta	183	183		Solid
Tellurium	Te	127	127.6	255	Solid
Thorium	Th	232	232.5		Solid
Tin	Sn	119	119		Solid
Tungsten	W	184	184		Solid
Zinc	Zn	65	65.4		Solid

posed into any other substances. Nothing but hydrogen can be obtained from hydrogen, and nothing but oxygen can be obtained from oxygen; in other words hydrogen and oxygen are regarded as *simple* or *elementary* substances. There are about seventy such simple or elementary substances called *elements*. Whether or not they are composed of simpler kinds of matter is not known positively—possibly some of them are—but at any rate they cannot at the present time by any known means, be decomposed or converted into simpler ones. Just as water is a complex substance, being made up of the elements, hydrogen and oxygen, so most of the substances which come under our observation are complex, being made up of two, three, four, or five elements. Many of the elements are rare, and only about twelve are found to be among those which enter into the composition of most of the substances with which we have to deal. In Table I is given a list of the more important elements.

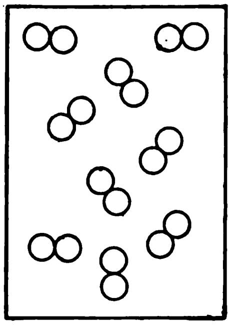
Fig. 1. Hydrogen Molecules

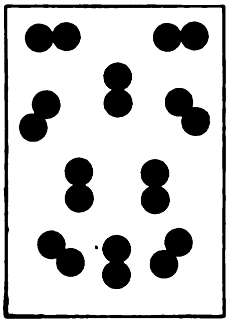
Fig. 2. Oxygen Molecules

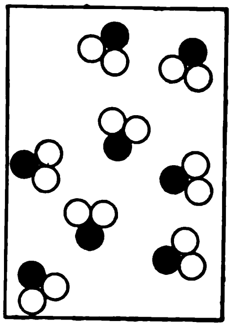
Fig. 3. Molecules of Water

Molecules and Atoms. The elements, and the substances of which they enter into the composition, are regarded as being made up of very small particles. Thus, hydrogen is made up of very small particles of hydrogen, and oxygen of very small particles of oxygen, and water of very small particles of water. If any given amount of water were divided and subdivided and so on, it is considered that finally very small particles of water would be obtained, which are themselves made up of two still smaller particles of hydrogen and oxygen united together very closely. The smallest particle of water which it would be possible to obtain would always be found to consist of two particles of hydrogen and one particle of oxygen. Such a particle of water is called a *molecule*, and the smaller particles of hydrogen and oxygen composing this molecule are called *atoms*. Thus, all matter, whether it be in the solid, liquid, or gaseous form, is regarded as being made up of very small aggregations of minute particles, or molecules, which are themselves made up of indivisible particles, or atoms. All the molecules of one kind of a substance are exactly alike, but quite different from the molecules of all other substances. The molecules of substances made up of more than one element consist of atoms of different kinds, while the molecules of elements consist of atoms of the same kind.

These conceptions are illustrated graphically in Figs. 1, 2, and 3. In Fig. 1, the combination of small circles represents molecules of hydrogen, each circle representing an atom of hydrogen. In Fig. 2, the molecules of oxygen are represented. In Fig. 3, the combination of circles represents molecules of water, each one of which is composed of an atom of oxygen and two atoms of hydrogen.

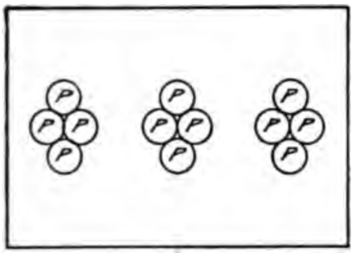

Fig. 4. Phosphorus Molecules

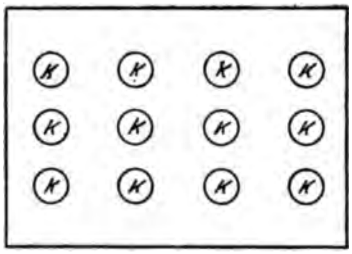

Fig. 5. Potassium Molecules

The molecules of most of the elements consist of two atoms, as is the case with hydrogen and oxygen. In the elements cadmium, mercury, potassium, sodium, and zinc, the molecules consist of only one atom, hence, the terms molecule and atom mean the same when applied to these elements. In the case of arsenic and phosphorus, the molecules consist of four atoms. The smallest body of phosphorus *P* that could exist alone, therefore, would consist of four smaller particles of phosphorus (atoms) united together, as shown graphically in Fig. 4. If these molecules are split up, the atoms immediately unite again with themselves or some other substance. In the case of potassium, however, the atoms remain single, when among themselves, as shown in Fig. 5. The actual size of a molecule has never been determined but it is certain that it is extremely minute.

The above conceptions of atoms and molecules form a working basis for studying the chemical changes which matter undergoes, and it is highly important that a clear understanding of them be obtained at the outset. The student should bear in mind that the terms, atom and molecule, are in constant use among chemists, as these terms are chemical units, so to speak, and greatly aid in the intelligent and systematic study of chemical changes. Whether or not these conceptions as to atoms and molecules are absolutely true is of no practical consequence; they form the best theory as yet advanced to account for the chemical behavior of matter, and the fact remains that if matter were so constituted as indicated, it would appear to us as it now does.

Compounds and Mechanical Mixtures. We have already seen that the molecules of one kind of a substance are always exactly alike; but that the atoms which compose the molecules of a substance may or may not be alike; thus, the atoms of oxygen molecules are all alike, while the atoms of the molecules of water are of two kinds, namely, hydrogen and oxygen. A substance made up of molecules having different kinds of atoms, as is the case with water, is called a compound; hence, water is a compound. Carbon monoxide is another compound, as its molecules consist of carbon and oxygen atoms.

Accordingly, matter may be divided into two general classes, elements and compounds. The compounds are made up of two or more dissimilar elements, and while there are only about thirty of the elements which are of a high degree of importance, the number of very important compounds runs into the thousands, and the total number is practically infinite. The compounds can all be broken down, or decomposed, into the elements which compose them; and just as many different kinds of matter may be obtained from a compound as there are different kinds of atoms present.

When different kinds of substances are brought in contact they may remain associated together without undergoing any chemical change; or, on the other hand, they may enter into combination with each other, forming a substance differing in properties from the original substances. When hydrogen and oxygen, for example, are brought together at ordinary temperatures, they simply remain mixed, no chemical change resulting. However, if the mixture is heated, a remarkable change takes place, resulting in the formation of the compound water. It is now no longer a mixture of hydrogen and oxygen gases, but a chemical compound. Before heat was applied the molecules of hydrogen and oxygen merely mingled together, and each remained unchanged. When substances remain in close association without losing their identity, that is to say, without entering into chemical union, the result is said to be a mechanical mixture. A mechanical mixture of hydrogen and oxygen is represented graphically in Fig. 6; compare with Figs. 1, 2, and 3. Sulphur and iron filings may be mixed as intimately as possible by grinding them together, but at ordinary temperatures no chemical union between the iron and sulphur takes place, and they remain associated together without losing their properties. The result is, therefore, a mechanical mixture. The iron can be separated from the mixture by means of a magnet. The sulphur can be removed by means of carbon disulphide. However, if the mixture is heated, a chemical change takes place, the molecules of sulphur combining with the molecules of iron; thus, a new substance is formed, which is a compound of iron and sulphur, but with properties quite different.

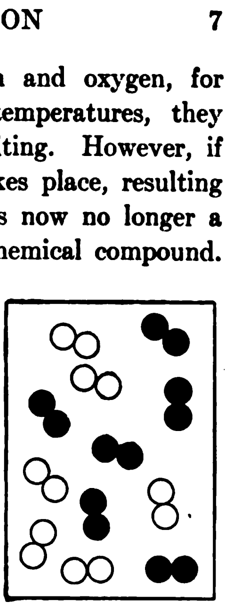

Fig. 6. Mechanical Mixture of Hydrogen and Oxygen

Experiment 1. Apparatus required: Two or three small glass test-tubes about 6 inches in length; a burner, preferably a bunsen burner, connected by flexible tubing with a gas supply; a steel magnet.

Chemicals required: A small quantity of sulphur and iron filings.

Powder the sulphur. Place a little on a small piece of steel or iron, and heat the sulphur till it takes fire. Note the color of the flame and the irritating odor. Have the sulphur dry and try the magnet on it. Mix intimately equal quantities of the sulphur and iron filings. Study this

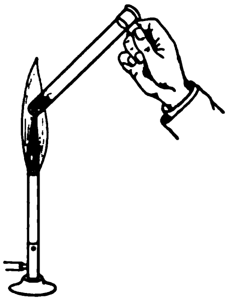

Fig. 7. Method of Heating Sulphur and Iron

mixture carefully. Divide it into two portions; try the magnet on one portion. Place the other portion in a test-tube, and heat it gradually, Fig. 7. Watch the behavior of the mixture during the heating. Continue the heating till the mass begins to glow. Heat for a second or two longer. Remove from the flame. Let it cool; break the tube. Examine the contents closely. The mass will be found now to have a bluish-black color. It no longer looks like a mixture of sulphur and iron. There may be a little sulphur or iron left because sulphur and iron combine chemically, as will be learned later, in a certain definite proportion, and if, before it is heated, there is an excess of either iron or sulphur in the mixture beyond the combining proportion, this excess is left over at the end of the experiment. However, most of the mass will be found to be neither iron nor sulphur. Break up the mass and note whether or not the magnet attracts it. The compound formed is known as iron sulphide.

CHEMICAL ACTION

When the elements, hydrogen and oxygen, combine chemically, forming the compound, water, the weight of water formed is exactly the same as the weight of hydrogen and oxygen taking part in the change. Hence, the change which takes place is not in the amount of matter, but in the composition of matter, and is, therefore, as we have learned, a chemical change. The atoms of one element have united with the atoms of another element, and molecules of a different order from those of hydrogen or oxygen have been formed. This process or rearrangement of the atoms which takes place when matter undergoes a chemical change is termed chemical action. Chemical actions are also called chemical reactions.

In Experiment 1, when the sulphur was heated it took fire and burned, forming a pungent gas. In other words, a chemical reaction occurred in which atoms of sulphur united with atoms of the oxygen of the air and formed molecules of sulphur dioxide.

Chemical reactions, in general, are of two kinds—chemical combination and decomposition.

Chemical Combination. Chemical combination is the uniting of elements or compounds or both to form one or more compounds. Examples of this kind of chemical action are furnished by the formation of water by the union of hydrogen and oxygen; of sulphur dioxide by the combination of sulphur and oxygen; and of iron sulphide by the combination of iron and sulphur. Most fires are chemical reactions of this order.

Decomposition. Decomposition is the breaking down of compounds into elements or simple compounds. Examples are afforded by the decomposition of water into hydrogen and oxygen by the electric current; and by the breaking down of potassium chlorate by heat into potassium chloride and oxygen, as will be shown later. In many cases of chemical reactions both combination and decomposition occur.

The process of producing a compound by bringing certain elements together so that they will combine chemically, is termed *synthesis.*

The process of determining the constituents of a compound by decomposing it, is termed *analysis.*

Cause of Chemical Action. That power which causes the atoms to unite to form compounds, is termed *chemical affinity.* It is regarded as an attractive force exerted by the atoms of the different elements which are endowed by nature with this tendency to combine. The atoms of each element have affinities which are different from the affinities possessed by the atoms of other elements. In other words, the atoms may be regarded as having a selective power. Under certain conditions the affinities of certain atoms are exerted, and under other conditions they are not. The application of heat usually causes the affinities of most elements to operate. Thus, in Experiment 1, when the mixture of sulphur and iron was heated, the affinity of the sulphur atoms for the iron atoms was exerted, and caused the chemical reaction which resulted in the formation of iron sulphide. Again, at ordinary temperatures the affinity of the oxygen of the air for sulphur is not exerted, but as soon as the sulphur is heated sufficiently, the affinity is exerted, and causes the chemical reaction to take place, which, as we have seen, consists in the burning of the sulphur.

Cause of Stability of Molecules. Chemical affinity not only causes chemical reaction to occur, but it holds together the atoms of the molecules of compounds; if this power should cease to operate, the compounds would be resolved or decomposed into their elements. For example, when a current of electricity is passed through the compound water, the affinities of oxygen and hydrogen atoms cease to operate and as a result, decomposition of the water into its elements ensues. In some cases the application of sufficient heat causes the affinities of certain elements to cease to operate, and, therefore, certain compounds may be decomposed by heat.

Catalytic Actions. Strange as it may seem, the presence of a third substance is essential to the occurrence of certain chemical reactions, owing to the fact that the affinities of the atoms of certain elements are not exerted except in the presence of some third substance, which, however, apparently remains unchanged. Such reactions as these are often designated as *catalytic* actions. For example, the elements, sodium and chlorine, have strong affinities for each other under common conditions (even at ordinary temperatures), and, under these common conditions, they combine, forming the compound, sodium chloride, known as common salt. However, under common conditions a certain amount of moisture is always present; if this moisture be removed and the sodium and chlorine be brought together under perfectly dry conditions, no chemical reaction occurs, showing that the affinities of the atoms of chlorine and sodium for each other do not operate when alone together and perfectly dry. The way in which the presence of moisture affects the affinities of atoms is not known.

Nascent State. When the atoms are liberated from a compound by chemical action (decomposition), they are said to be in the *nascent state* at the moment the uncombined atoms are first liberated. Certain elements, at the instant they are set free from a compound, that is to say, when they are in the nascent state, exert a powerful affinity for certain substances toward which these same elements may show no chemical affinity under ordinary conditions. Thus, hydrogen when brought in contact with many substances under ordinary conditions does not show any tendency to react with them. But if hydrogen is brought in contact with some of these substances at the instant it is set free from a compound (even at ordinary temperatures) it shows a strong affinity, and readily enters into chemical combination. Many substances are in contact with the oxygen of the air, but no action takes place at ordinary temperatures, because the affinity of the oxygen does not operate. There are, however, certain compounds of oxygen which readily liberate oxygen, and these compounds (carriers of oxygen) may cause fire, as we shall see, because they supply oxygen in the nascent state, in which it unites readily with many substances.

Valence. That power which determines the number of other atoms with which an atom may unite is termed its *valence;* it must not be confused with the strength or intensity of the affinity of an atom. The valence of an element, therefore, determines how many atoms of any element may combine with those of any other element. The atom of chlorine combines with only one atom of hydrogen, and, therefore, there is only one compound of hydrogen and chlorine, namely, hydrochloric acid, HCl. An atom of oxygen can combine with two of hydrogen, as it does in the compound water, H_2O. One atom of nitrogen can combine with three of hydrogen, as is shown by the compound ammonia, NH_3. One atom of carbon can unite with four atoms of hydrogen to form the compound methane, CH_4. An element like chlorine or hydrogen is called a *univalent* element; while an element like oxygen whose atom can combine with two atoms of hydrogen, is termed a *bivalent* element. Nitrogen is accordingly spoken of as a *trivalent* element, and carbon as a *quadrivalent* element. The valence of elements toward hydrogen is generally constant, but toward many other elements it varies.

Chemical Affinity and Molecular Forces. It is important that a clear distinction be made between chemical affinity and those physical forces which control the molecules. The force which holds the molecules of a solid together—cohesion—and that which causes the molecules of a gas to fly apart—due to molecular motions—are regarded as physical forces, and must not be confused with chemical affinity, which controls the atoms. For example, the force which holds the molecules of a piece of ice together at freezing temperatures so that it is hard and brittle is quite different from the force (chemical affinity) which holds the atoms of hydrogen and oxygen united. Accordingly, when the ice is heated, the affinity of the atom is not affected and the compound still exists, but the force of attraction between the molecules is affected to such an extent that it admits of a change in the form of the water, viz, from the solid form to the liquid form.

ATOMIC AND MOLECULAR WEIGHTS

One of the most characteristic properties of atoms is that of weight, and although the absolute weights of the atoms and molecules can only be estimated, yet it is known from chemical considerations that they have definite weights. On the other hand, the *relative* weights of the various atoms have been determined, and are known as *atomic weights.*

The atomic weights are universally referred to the oxygen standard, in which the atomic weight of oxygen is taken as 16 units; that is to say, the unit of weight of the system has been arbitrarily fixed as one-sixteenth the weight of an atom of oxygen. The atomic weight of hydrogen is approximately one-sixteenth the atomic weight of oxygen, or unity. Accordingly the atomic weight of hydrogen is often referred to as the *unit* in less exact systems. When we say the atomic weight of carbon is 12, we mean that the atoms of carbon weigh twelve times as much as one-sixteenth of the weight of oxygen atoms. Roughly the atomic weight of carbon is twelve times that of hydrogen (1.008).

The atomic weights are abstract numbers, and accordingly represent any units of weight chosen, such as pounds, grams or grains. Thus, the atomic weight of carbon, 12, means 12 grams or 12 grains or 12 pounds according to the units of weight chosen. In other words, it expresses the fact that if a certain number of hydrogen atoms weigh 1 gram, the same number of carbon atoms weigh 12 grams, or if a certain number of hydrogen atoms weigh 1 pound, the same number of carbon atoms weigh 12 pounds.

The relative weight of a molecule is the sum of the relative weights of the atoms composing it. Thus, when the molecule of an element consists of two atoms, the molecular weight of that element is twice the atomic weight.

Table I gives the atomic weights of some of the more important elements, and also a number of molecular weights.

CHEMICAL SYMBOLS

We have learned that when one substance acts upon another, a rearrangement of the atoms takes place; to represent the results of such chemical action certain symbols are used to represent atoms, molecules, and chemical changes, a method which is very convenient and which cannot well be dispensed with.

Atomic. The symbols for the atoms of the more important elements are found in Table I. It should clearly be understood at the outset that the symbol of an element is not only an abbreviation, but denotes a single atom; thus, H not only stands for the element hydrogen, but denotes one atom of hydrogen; S stands for one atom of sulphur; and O stands for one atom of oxygen.

Molecular. (Compounds). The molecule of an element is represented by the symbol of the element, followed by a small numeral which indicates the number of atoms in the molecule represented; thus, as the molecule of hydrogen consists of two atoms of hydrogen, H_2 represents a molecule of hydrogen. If the molecule of hydrogen consisted of three atoms, then, the symbol H_3 would be used to represent it. As a molecule of the element oxygen consists of two atoms, O_2 is used to represent it. P_4 represents a molecule of phosphorus, which, as we have seen, consists of four atoms. The molecules of the elements, sodium, potassium, mercury, and zinc, consist of a single atom, and are accordingly indicated by the symbols Na, K, Hg, and Zn. (The small numeral 1 being omitted.)

A molecule consisting of different kinds of atoms—that is, a compound—is represented by the united symbols of the constituent atoms. Thus, a molecule of the compound sodium chloride, which consists of one atom of sodium combined with one atom of chlorine, is represented by the united symbols of sodium and chlorine, NaCl.

When a molecule of a compound contains more than one atom of the same element a small numeral of the proper denomination is placed immediately after the symbol of the atoms present in plural number. For example, a molecule of water, which consists of two atoms of hydrogen and one atom of oxygen, is represented by H_2O. A molecule of ammonia consists of an atom of nitrogen united with three atoms of hydrogen and is accordingly represented by the united symbols NH_3 (or H_3N).

A group of more than one molecule of an element or of a compound is represented by placing a numeral immediately before the symbol of the molecule. Thus, two molecules of water are denoted by $2H_2O$. $3H_2O$, therefore, represents three molecules of water; 2NaCl represents two molecules of sodium chloride; $4NH_3$ represents four molecules of ammonia; $2O_2$ represents two molecules of oxygen.

Certain groups of atoms, as NH_4 and OH, are found in many different molecules, and are often called *radicals*. They are often enclosed by means of parentheses or brackets. Thus, calcium hydroxide (slaked lime) is usually represented by $Ca(OH)_2$ instead of by CaO_2H_2. This compound consists of one atom of calcium united with two atoms of oxygen and hydrogen. It is seen that in the molecule of calcium hydroxide the OH group occurs twice. When such groups occur only once in a molecule, they are not usually set off in parentheses or brackets; thus, sodium hydroxide is represented by NaOH; potassium hydroxide by KOH. NH_4Cl represents ammonium chloride, consisting of the group, NH_4: one atom of nitrogen, with four atoms of hydrogen (a radical), and also one atom of chlorine.

Formulas. The united symbols representing a molecule of a compound are known as the formula for that compound; for example, H_2O is the formula for water.

Chemical Equations. As stated above, the symbols are used in expressions to represent the results of chemical reactions. Such expressions are known as chemical equations.

Suppose it is desired to represent what takes place when carbon burns in the air. When carbon burns, one atom of carbon unites with two atoms (a molecule) of oxygen, forming a molecule of the gas, carbon dioxide. Carbon dioxide consists of one atom of carbon combined with two atoms of oxygen, CO_2. The reaction is represented in an equation thus, $C+O_2=CO_2$. In writing chemical equations, the symbols of the substances (formulas) taking part in the reaction are placed on the left side of the equation, and the symbols of the substances formed by the reaction are placed upon the right. When sulphur burns in the air the atoms of sulphur unite with the atoms of oxygen of the air and the gas, sulphur dioxide, is formed; this reaction is accordingly represented by the equation $S+O_2=SO_2$.

CERTAIN LAWS OF MATTER

Indestructibility of Matter. Matter can neither be created nor destroyed. This is the fundamental law on which the science of chemistry is based, and shows that although transformations or changes in matter may be brought about in various ways, the total amount of matter after any transformation or change is the same as before. Matter may apparently disappear, as in a fire, but it continues to exist in some form. For example, when sulphur burns it unites with the oxygen of the air, forming an invisible gas, but the weight of the gas formed is always equal to the weight of the sulphur burned, plus the weight of the oxygen of the air which took part in the reaction.

Constant Composition. *The same compound, whatever its origin, always contains the same kind of elements united in exactly the same proportions by weight.* This is also known as the law of definite proportions. As we have already seen, substances may be present in any proportion in a mechanical mixture, but in a chemical compound the elements are invariably combined in a definite proportion. For example, the compound water always consists of the two elements, hydrogen and oxygen, combined in the proportion by weight, of 1 to 8. Water may be made synthetically from the elements hydrogen and oxygen, or obtained from rivers, springs, snow, rain, the air, wood, or by burning hydrogen, but no matter how obtained, it invariably contains the same two elements in the same proportions. If a mixture of hydrogen and oxygen containing an excess of either element beyond the combining proportion, be prepared, and subjected to conditions which will cause chemical action to take place, every sixteen parts by weight of oxygen present in the mixture will unite with two parts by weight of hydrogen to form water, and the *excess* of either element present will remain unacted upon.

Some elements combine with each other to form more than one compound, but the proportions by weight in each compound are constant. For example, carbon unites with oxygen, forming the inflammable gas, carbon monoxide, CO, in the proportion, 12 parts by weight of carbon to 16 parts by weight of oxygen (1 to 1.3), and also with oxygen, to form the non-inflammable gas, carbon dioxide, CO_2, in the proportion, 12 parts by weight of carbon to 32 parts by weight of oxygen (1 to 2.66). Here we have two distinct compounds, both containing $C+O$, and conforming to the general law.

CLASSIFICATION OF COMPOUNDS

Acids. An acid is a compound which contains the element hydrogen in combination in such a state that it is capable of being replaced by a metal; the hydrogen is in combination with an element or group of elements, usually including the element oxygen. When an acid, therefore, reacts with a metal, ordinarily the metal takes the place of the hydrogen in the acid, and the hydrogen is liberated. Thus, when sulphuric acid acts on the metal zinc, hydrogen is evolved and the zinc takes its place, forming zinc sulphate (a salt). The reaction is represented by the equation

$$Zn + H_2SO_4 = H_2 + ZnSO_4$$

Acids also have the property of neutralizing, that is, destroying the characteristic properties of a class of compounds called bases. When an acid and base are brought together, in the proper proportions, the characteristic properties of the acid are also destroyed. Hence, we say acids and bases have the power to neutralize each other. Hydrochloric acid, HCl, nitric acid, HNO_3, and sulphuric acid, H_2SO_4 are very important acids, and are commonly termed *mineral acids.*

Bases. The most important bases are: Sodium hydroxide (soda), $NaOH$, potassium hydroxide (potash), KOH, and calcium hydroxide (slaked lime), $Ca(OH)_2$.

A base which is readily soluble in water is often called an alkali. Ammonia in solution in water forms the hydroxide, NH_4OH, which acts like a base.

As stated above, when an acid and base are brought together, they neutralize each other. Thus, hydrochloric acid and sodium hydroxide combine to form water and sodium chloride:

$$HCl + NaOH = NaCl + H_2O$$

A base has properties, therefore, opposed to the properties of an acid. Acids change blue litmus (a vegetable blue) to red, while bases change the red litmus back to blue. Bases are said, therefore, to have an alkaline reaction, while acids have an acid reaction.

Salts. When an acid and base react with each other, the compound formed is neither an acid nor base, but is usually termed a salt. Hence, sodium chloride, $NaCl$, is a salt. In addition, the compound formed by replacing the hydrogen of an acid with a metal is termed a salt; thus, zinc sulphate is a salt. Some salts are neutral, that is, have neither acid nor basic properties. Many salts, how-

A CHARACTERISTIC WINTER FIRE SCENE

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

ever, have weak acid or basic properties, and are accordingly termed acid salts, or basic salts. Salts formed by the action of HCl on bases or metals are termed chlorides, and likewise salts derived from sulphuric acid are termed sulphates. So we have chlorides, sulphates, nitrates, and many other classes of salts.

There are many compounds which are neither acids, bases, nor salts, but an extended treatment of this subject does not properly come within the scope of this book. The student desiring further information along the above lines is referred to more general works on chemistry.

PROPERTIES OF GASES

Charles' Law. When a gas is heated it expands or increases in volume; conversely, when a gas is cooled it contracts. It was found by Charles that *all gases when heated increase in volume to the same extent.* When one volume of any gas is heated from 0°C. to 1°C. the amount of increase in volume is about .003665, or roughly $\frac{1}{273}$ of the volume heated; thus, one cubic centimeter of a gas at 0°C. becomes 1+.003665 cubic centimeters at 1°C. 96.5 cubic centimeters of a gas at 0°C. would accordingly expand to a volume of approximately 100 cubic centimeters at 10°C.

Boyle's Law. The effect of pressure on gases is to diminish their volume; in other words, gases are compressible. When the pressure is doubled, the volume of the gas becomes one-half, and so on; conversely, when the pressure is reduced one-half, the volume is doubled. The law may be stated as follows: *The volume of any gas varies inversely as the pressure.*

While these important laws of Charles and Boyle are not absolutely true, the extent to which they are deviated from in the case of gases is so small as to be practically negligible. It will be evident from their consideration that the volume which any given weight of gas occupies depends on both the temperature and the pressure. If the pressure is reduced or the temperature is raised, the gas expands; on the other hand, if the pressure is increased or the temperature is reduced, the gas contracts. Hence, *if a gas is heated in a confined space the pressure will be increased by an amount depending on the temperature to which the gas is heated.* The importance of this fact will be made evident when we come to study explosives.

TABLE II

Critical Temperatures and Pressures

Substance	Symbol	Critical Point Centigrade	Critical Pressure Atmospheres
Hydrogen	(H_2)	−240	15.3
Oxygen	(O_2)	−118.8	58
Acetylene	(C_2H_2)	35	61
Carbon Dioxide	(CO_2)	31.3	72.3
Ammonia	(NH_3)	131	113
Sulphur Dioxide	(SO_2)	155.4	78.9

Liquefaction of Gases. When a gas is subjected to a sufficiently high pressure and low temperature (different for each kind of gas), it passes from the gaseous state to the liquid state. It is evident, therefore, that at the pressure and temperature at which a gas passes into the liquid condition, the law of Charles and the law of Boyle do not apply.

Critical Point. It has been found that for any gas, there is a certain temperature above which no amount of pressure will liquefy that gas. This temperature is called the critical point, or critical temperature, of the gas. For example, the critical temperature, or critical point, for carbon dioxide is approximately 31.3°C.; therefore, above this point no amount of pressure will liquefy carbon dioxide. The critical temperatures of gases vary through a wide range.

Critical Pressure. The pressure required to liquefy a gas at its critical temperature is known as the critical pressure of the gas. It requires less pressure than the critical pressure to liquefy a gas at temperatures below the critical temperatures. The critical temperatures and pressures of a few gases are given in Table II. The figures given are probably the most reliable published, but have not been finally shown to be absolutely true values.

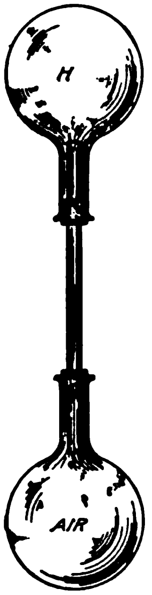

Fig. 8. Diffusion of Gases

Diffusion of Gases. If the apparatus, Fig. 8, be so arranged that the upper glass bulb is filled with hydrogen and the lower bulb with air, the hydrogen will not float on the air, although the latter is about 14 times as heavy as hydrogen, but gradually makes its way into the lower bulb, and the air gradually moves into the upper bulb; this process continues until the hydrogen and the air form uniform mixtures in each bulb. This is explained on the supposition that the molecules of gases are in constant motion, and consequently when two gases are brought together, this motion of the molecules brings about the intermixture of the gases. This process of intermixture of gases caused by the motion of the molecules is called *diffusion.*

The molecules of all gases, however, do not move with the same velocity even when the temperatures of the gases are the same, and hence, certain gases intermix, that is, diffuse more rapidly than others. The process of diffusion of two gases is shown graphically in Fig. 9, the molecules of each gas being shown as moving about in all directions, often colliding with each other, but gradually working their way into the space previously occupied by the molecules of the other gas. The light gases diffuse much more rapidly than the heavy ones, the law of gaseous diffusion being, *the rate of diffusion of any two gases varies inversely as the square roots of their densities.* Hydrogen, for example, diffuses nearly four times as fast as air. Light gases readily diffuse through porous materials, and are consequently more difficult to keep confined in certain vessels. Gaseous diffusion plays an important part in the formation of explosive mixtures of gases and air, as will be seen later.

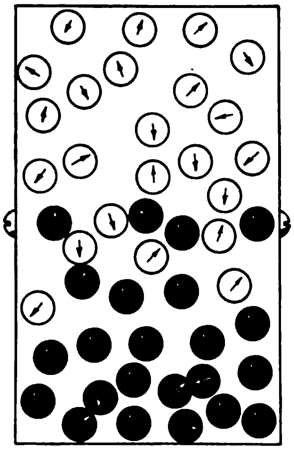
Fig. 9. Molecular Diagram of the Process of Diffusion

PROPERTIES OF LIQUIDS

Evaporation. We have already learned that when matter is in the gaseous state the molecules are in motion. This is also true of the liquid state, although in the latter case, the motion of the molecules is restricted by their mutual attraction. As a liquid readily changes its shape, the force of mutual attraction of the molecules is regarded as almost balanced by the tendency of the molecules to break away, owing to their motion. When a liquid is exposed to the air, some of the molecules at the surface do break away, that is, overcome the forces of mutual attraction and move about in the space above the liquid, and as a result the liquid diminishes in quantity. This process is called *evaporation.*

If the space above the liquid is limited, it will finally become filled with the escaping molecules, and as many molecules will then come back in contact with the surface of the liquid, in a given time, as leave it and, as a result, the evaporation will apparently cease. On the other hand, if the molecules which escape from the surface of the liquid are swept away, say by a current of air, the rate of evaporation is increased. Again, evaporation is more rapid in a vacuum because the molecules that escape from the surface of the liquid are not retarded in their motion by the presence of molecules of air.

As the molecules of a liquid move faster when the liquid is heated, the higher the temperature of a liquid, the greater is the number of molecules which escape from the surface in a given time and, consequently, the higher is the rate of evaporation.

The molecules which escape from the surface of a liquid during evaporation are spoken of as the *vapor of the liquid.*

Gas and Vapor. The terms gas and vapor are sometimes applied to all aëriform substances. It is proper and convenient, however, to apply the term *gas* to substances which exist in the gaseous state under the ordinary conditions of temperature and pressure; for example, hydrogen, oxygen, air, nitrogen, carbon dioxide, ammonia, acetylene, and coal gas belong to this class, and are spoken of as permanent gases, although they may be liquefied at low temperature by means of a high pressure. The term *vapor* is generally applied to substances in the gaseous state that under ordinary conditions exist in the liquid state; thus, gaseous alcohol, gaseous gasoline, and gaseous water (steam) are vapors. The vapors of ether, benzine, turpentine, and carbon disulphide belong to this class.

Vapor Pressure. If the vapor which escapes from the surface of a liquid be confined in a space above the liquid, it will be found that the confined vapor exerts a definite pressure, which will depend on the nature of the liquid and the temperature. This pressure resulting from the tendency on the part of a liquid to evaporate is called the. vapor pressure, or vapor tension, of a liquid. It has different values for different liquids, and shows an increase with a rise of temperature.

Boiling Point. Many liquids, such as water, for example, pass off in the form of vapor at ordinary temperatures, and the amount of vapor evolved in a given time increases with the temperature. If heat is continuously added to a liquid, the temperature of the liquid rises until a point is reached at which its temperature remains stationary and the liquid freely passes into vapor. This phenomenon is known as *boiling*. If a great deal more heat is applied the liquid simply boils away faster, but its temperature remains unchanged. The same liquid always boils at the same temperature, provided the pressure on the liquid is the same. Increase of pressure raises the temperature of boiling, while decrease of pressure lowers it. When a liquid is heated to boiling in an open vessel in teh air, the liquid is said to boil under atmospheric pressure. The pressure of the atmosphere varies considerably at different times; for this reason a standard of pressure has been adopted called an *atmosphere,* which is equivalent to the pressure exerted by 760 millimeters of mercury (approximately 14.7 lbs. per sq. in.). The temperature at which a liquid boils under standard pressure is called the boiling point of the liquid. Thus, water boils at 100°C. under 760 millimeters pressure, and hence 100°C. is the boiling point of water. The boiling point of ether is 35°C. and of alcohol 78°C. The boiling point may be more scientifically defined as *the temperature at which the vapor pressure is equal to the standard pressure of the atmosphere.*

Volatility. The term *volatile* is applied to substances which are capable of being readily converted into gases or vapors by heat. Nearly all solids pass into the gaseous form at high temperatures. Substances which require a very high temperature to render them gaseous are called non-volatile, while substances which become gaseous at temperatures below a red heat are usually considered as volatile. For example, ether, gasoline, carbon disulphide, alcohol, water, and camphor are volatile substances.

How volatile an inflammable liquid is, is a very important question when considering its relative combustibility, as will be seen later on. The vapor pressure of a liquid at ordinary temperatures is a measure of its relative volatility under common conditions, while the boiling point is often a measure of the volatility at higher temperatures.

Solution. When common salt is immersed in a sufficient amount of water, it soon disappears and cannot then be separated from the water by filtration, nor will it separate out on allowing the water to stand. The salt is said to have dissolved in the water, or to have gone into solution. It may be recovered by evaporating the water, when the salt will be left behind unchanged. If, however, paraffin wax be immersed in the water, no solution takes place, the wax remaining in the solid form. Substances which do not dissolve in a liquid are said to be insoluble in that liquid; thus, paraffin wax is insoluble in water. On the other hand, it is readily soluble in ether and certain other liquids.

Liquids are not only capable of dissolving certain solids, but also many gases and certain other liquids. For example, 100 volumes of water dissolve about 180 volumes of carbon dioxide at a temperature near the freezing point of water. A rise in temperature usually decreases the solubility of a gas in a liquid—as evidenced by the fact that a liquid containing gases gives them off on being heated—while, on the other hand, a rise in temperature usually aids the solution of solids in liquids; thus, a given quantity of water when hot will dissolve more salt than when cold. The solubility of most liquids in liquids is also increased by heat.

Liquids which are soluble in one another in all proportions are said to be *miscible* with each other in all proportions; thus, alcohol and water are miscible in all proportions as they are capable of forming homogeneous mixtures when added together in any quantity whatsoever.

Some liquids dissolve in one another only to a limited extent, and are said to be partially miscible. Liquids which do not form solutions with one another are said to be *immiscible.* For example, when carbon disulphide and water are brought together and shaken up in a vessel, they immediately separate into two layers, the water floating on the carbon disulphide.

OXYGEN

Synonym, Vital Air Symbol, O
Atomic Weight, 16 Molecular Weight, 32

We come now to study one of the most important elements with which we have to deal, an element which, we shall learn later on, is as essential to the occurrence of most fires as the combustible materials themselves.

Occurrence. Oxygen is necessary to all forms of vegetable and animal life. It constitutes about one-fourth of the volume of the earth's atmosphere, about one-half of the earth's crust, and about eight-ninths (by weight) of the water. It exists as free oxygen—that is, uncombined chemically—in the atmosphere, but occurs in the earth's crust in the combined state.

Preparation. Oxygen may conveniently be prepared by heating certain of the compounds containing it in the combined state. Thus, when mercuric oxide, HgO—a compound consisting of mercury and oxygen—is heated, it is decomposed into mercury and oxygen, as represented by the equation

$$HgO = Hg + O$$

Experiment 2.—See Fig. 10. Apparatus required: A hard glass tube (or ignition tube) closed at one end—about 6 inches in length and ½ inch in diameter; a clamp for holding the tube; a burner; several splinters of wood; a few feet of very fine iron wire.

Chemicals required: About 10 grams of mercuric oxide.

Heat a few grams of mercuric oxide in the glass tube, heating the tube gently at first and gradually increasing the heat until the oxide begins to decompose (shown by the separation of mercury). Introduce a glowing splinter of wood into the tube, which should now contain oxygen; note how the splinter burns. Introduce a piece of fine iron wire heated to redness. The iron burns brilliantly in the oxygen.

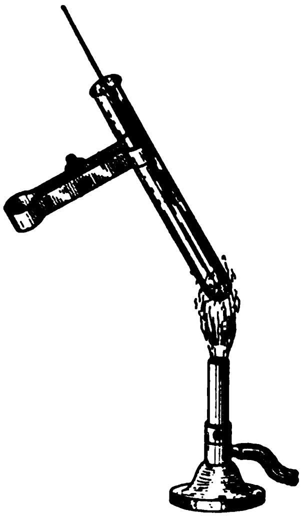

Fig. 10. Decomposition of Mercuric Oxide by Heat

Experiment 3.—See Fig. 10. Apparatus required: Same as in experiment 2.

Chemicals required: About 5 grams of potassium chlorate; an equal quantity of manganese dioxide.

Heat a few crystals of potassium chlorate in the tube. It soon melts, and a little later begins to give up oxygen. The presence of the oxygen may be shown by introducing into the tube a splinter with a spark at the end, when the splinter will burn rapidly.

Try the same experiment with a mixture of potassium chlorate and manganese dioxide, equal quantities of each. The oxygen formed in this case is not as pure as that formed with the chlorate alone. Introduce some of the wire heated to redness.

Caution. The above experiments should not be conducted in the vicinity of inflammable materials.

Potassium chlorate, $KClO_3$, as indicated by its formula, consists of the elements potassium, chlorine, and oxygen chemically combined, so that each molecule of the compound contains one atom of potassium, one atom of chlorine, and three atoms of oxygen. As the atomic weight of potassium is 39, that of chlorine is 35.5, and that of oxygen is 16, the molecular weight is $39 + 35.5 + (16 \times 3) = 122.5$. From this we see that 122.5 grams of the compound contain 48 grams of oxygen. Some of this oxygen is loosely combined, so to speak, and the compound readily parts with this portion of its oxygen under certain conditions; for this reason, as will be seen later, it is one of the most hazardous chemicals with which the fire insurance interests have to deal. When heated alone, it first melts, then begins to decompose, evolving oxygen. If mixed with about one-fourth its weight of manganese dioxide it gives up oxygen at a much lower temperature. The exact part which the manganese dioxide plays in the chemical change is not known; but its presence in some way favors the reaction; at the end of the reaction the manganese dioxide remains unchanged, and may be used again.

Properties of Oxygen. The properties of oxygen are conveniently considered under two heads, namely, physical and chemical. In studying the properties of oxygen and other elements it is well to bear in mind that the physical properties of a substance depend on its molecules, while the chemical properties depend on its atoms. (See page 11.)

Physical. Oxygen is a gas, without color, odor, or taste. Its specific gravity is 1.105 (air = 1). 100 volumes of water absorb about 4 volumes of oxygen. When cooled to a temperature of about 118°C. below zero under a pressure of 50 atmospheres, it liquefies, forming a pale steel-blue liquid.

Chemical. Oxygen is one of the most active elements known. It has a remarkable chemical affinity, and unites at ordinary temperatures with phosphorus, potassium, and sodium; and in very moist air it unites with iron, forming rust. At higher temperatures it is capable of entering into combination with nearly all of the elements, and also with a very large number of compounds. However, even at high temperatures, the presence of a third substance seems to be essential to the chemical combination of oxygen with other substances, and this third substance, under practical conditions, is usually the moisture which is always present to a greater or less degree. Consequently, all that is necessary to cause the combination of oxygen with most materials under ordinary conditions is the application of sufficient heat.

The act of chemical combination or reaction of oxygen with certain bodies which come under our observation is attended by the evolution of light and heat, and is known as *combustion.* Practically all fires are examples of the rapid combination of the oxygen of the air with some substance. Such substances are called *combustibles,* and oxygen is called the supporter of combustion. The compound formed when oxygen enters into combination with an element is called an *oxide,* and the substance receiving the oxygen is said to *undergo oxidation.* Oxidation is a broader term than combustion, however, and includes all processes of direct combination of oxygen with substances, whether the process takes place rapidly as in the case of a fire, or so slowly as to hardly be perceptible, as in the case of the rusting of iron.

Before going deeper into the subject of combustion it is desirable to study some of the elements for which oxygen has a strong affinity; and the atmosphere which, as we have seen, is about one-fourth oxygen; and also some of the heat changes which accompany oxidation and combustion. The compound, water, will also be discussed, owing to its marked effect upon burning substances.

HYDROGEN

SYNONYM, Inflammable Air SYMBOL H
ATOMIC WEIGHT, 1.008 MOLECULAR WEIGHT, 2.016

Occurrence. Hydrogen occurs in small quantities in the free, or uncombined, state. In chemical combination with other elements it is very common. Many important compounds, such as water and all acids, contain hydrogen; it is also an important constituent of coal gas.

Preparation. Hydrogen is most conveniently prepared by treating zinc with hydrochloric or sulphuric acids. Hydrochloric acid, HCl, as indicated by its formula, is compcsed of hydrogen and chlorine united in the proportions, 1 part by weight of hydrogen to 35.5 parts by weight of chlorine; that is to say, 36.5 grams of pure hydrochloric acid (gas) contain 1 gram of hydrogen. The hydro-chloric acid found on the market is the gas in solution in water. Now, when hydrochloric acid is brought in contact with zinc (Zn) the affinity of the chlorine for the zinc is exerted and, as a result, the chlorine disengages itself from the hydrogen, and enters into combination with the zinc, forming the salt, zinc chloride. The reaction is represented by the equation

$$Zn + 2HCl = H_2 + ZnCl_2$$

(Two molecules of acid react with one molecule of zinc, forming one molecule of hydrogen and one molecule of zinc chloride.)

Experiment 4.—Apparatus required: A small test-tube about 6 inches in length.

Fig. 11. Formation of Hydrogen Gas

Chemicals required: Some small pieces of zinc; about 10 c.c. of ordinary hydrochloric acid.

In a test-tube put some small pieces of zinc (enough to make a layer from ⅛ to ¼ of an inch in depth), and pour upon it enough ordinary hydrochloric acid (previously diluted with an equal volume of water) to cover it. See Fig. 11. The gas liberated is hydrogen. Pure hydrogen is odorless, but the gas evolved in the experiment has an odor due to small amounts of other gases, formed by the action of the acid on impurities in the zinc. After the action has continued a minute or two, wrap the tube in a moist towel as a precaution, and apply a lighted match to the mouth of the tube. The hydrogen will take fire and burn.

Properties. *Physical.* Hydrogen is a colorless, inodorous, and tasteless gas. It can be liquefied under pressure at very low temperatures. It is the lightest of the known elements, being about 14.4 times as light as air.

Although hydrogen is much lighter than air, it will float on air for a short time only (unless confined in a light container) owing to the fact that the rate of diffusion of hydrogen in air is very rapid. (See page 19.) Hydrogen passes very rapidly (diffuses) through porous substances such as paper and earthenware.

Chemical. Hydrogen is not as active an element as oxygen. It does not, for example, enter readily into combination with iron, phosphorus, carbon, and sulphur, as does oxygen. It has a strong affinity for oxygen which is not exerted at ordinary temperatures; at high temperatures hydrogen readily unites with oxygen, and the combination is accompanied by the evolution of a great deal of heat and light—in other words, hydrogen burns in oxygen. It also burns in the air which, as we have seen, contains oxygen; hydrogen is, therefore, a combustible. The burning of hydrogen in the air is represented by the equation

$$2\ H_2 + O_2 = 2\ H_2O$$

Two molecules of hydrogen unite with one molecule of oxygen, forming two molecules of water. The hydrogen flame is slightly blue and non-luminous, but very hot. When a flame is applied to a mixture of hydrogen and oxygen the combination or combustion starts at the point of application of the flame, and spreads through the mixture rapidly, and may, in case the gases are confined, produce great pressure on account of the expansion produced by heating the gases. (See page 17.) When a flame is applied to hydrogen out of contact with the air, no combustion occurs as hydrogen has nothing in this case to support its combustion. In other words hydrogen will not burn in hydrogen. Fig. 12 represents an inverted tube filled with hydrogen, which, if lighted by a taper, will burn at the mouth of the jar where there is oxygen. If the taper is thrust up into the tube, the taper will be extinguished as it does not burn in hydrogen.

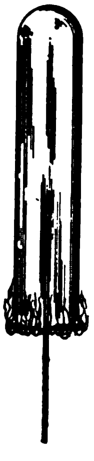
Fig. 12.
Burning Hydrogen

As hydrogen will burn in oxygen, so oxygen will burn in hydrogen, but not so with materials, such as paper, wood, and coal, for which hydrogen has no marked chemical affinity. In fact, most combustibles are non-combustible in hydrogen, and hence it is said of hydrogen that it is not a supporter of combustion.

WATER

Symbol, H_2O Molecular Weight, 18

Occurrence. Water may be regarded as an oxide of hydrogen, H_2O. It is formed in all common cases of combustion; thus, as we have seen, the burning of hydrogen in the air results in the formation of water. Water occurs in the air in vegetable and animal substances, and in a great many chemical compounds.

Properties. *Physical.* Pure water is odorless and tasteless; when viewed in small quantities it appears colorless, but when seen in a layer of considerable thickness it presents a bluish color. When heated to a temperature of 100° C. under a pressure of 760 millimeters of mercury, it boils, changing from a liquid to a vapor, termed *steam.* Steam is invisible, but when cooled, as happens when it is allowed to come in contact with the air at ordinary temperatures, it forms minute drops of water which are visible and are often called steam. Increase of pressure raises the boiling point of water, and decrease of pressure lowers it.

When cooled, water contracts (occupies less volume) until the temperature of 4°C. is reached; at this temperature water is at its maximum density. When cooled further it begins to expand, freezing to a solid (ice) at 0°C. Water is only slightly compressible.

Chemical. When the affinities of the atoms of a compound are so strong that under most conditions, the compound is very hard to decompose, it is said to be a *stable compound;* thus, water is a stable compound, capable, as we have seen, of undergoing many physical changes without suffering any change in composition. At very high temperatures, however, (1000°C. to 2500°C.) water is broken down into its elements.

Water unites with the elements, calcium, Ca, potassium, K, and sodium, Na, forming the bases, calcium hydroxide, potassium hydroxide, and sodium hydroxide.

$$Ca + 2H_2O = Ca(OH)_2 + H_2$$
$$K + H_2O = KOH + H$$
$$Na + H_2O = NaOH + H$$

These reactions are due to the strong affinity of Ca, K, and Na for oxygen, so that, when brought in contact with water, they unite with the oxygen of the water, thus liberating the element hydrogen which, as we have seen, is inflammable. The combination of potassium with the oxygen of the water is attended by the evolution of a great deal of heat, usually sufficient to set fire immediately to the liberated hydrogen. The action of sodium on water is also violent, but the heat evolved does not generally set fire to the evolved hydrogen as the sodium moves around on the water so rapidly that the hydrogen does not become heated sufficiently to ignite. If, however, the sodium is held in one place for a few seconds, in contact with the water, the hydrogen is ignited.

EXPERIMENT 5.—Apparatus required: Forceps; vessel of water; matches.

Chemicals required: A few pieces of sodium about the size of a pea. Sodium is kept under kerosene oil and it is advisable to buy it already cut in small pieces. The hands should not be brought into contact with the sodium; use the forceps.

Throw a small piece (never a large piece) of sodium on water and apply a lighted match to the floating sodium. Enough of the sodium burns to color yellow the flame produced by the burning hydrogen. Most of the sodium forms NaOH, which dissolves in the water.

Water unites readily with calcium oxide (lime) CaO, and also with the oxides of potassium and sodium, the reaction in each case being accompanied by considerable evolution of heat. Thus, when CaO is mixed with water the compound formed is $Ca(OH)_2$, and the heat evolved is sufficient, under favorable conditions, to cause fires.

Water is capable of taking into solution a larger number of substances than any other liquid, and it is therefore used as far as possible as a solvent in chemical analyses to bring about any desired chemical reactions. A great many chemical compounds are met with in solution in water.

Water is also a very important compound for extinguishing fires. This subject will, however, be treated separately

NITROGEN

SYMBOL, N ATOMIC WEIGHT, 14 MOLECULAR WEIGHT, 28

Occurrence. In the free state, that is to say, uncombined with other elements, nitrogen occurs in large quantities, constituting about four-fifths of the atmosphere; it also occurs combined with certain elements in a large number of compounds, being found in nitrates such as potassium nitrate (nitre-saltpeter), KNO_3, sodium nitrate, $NaNO_3$; also in ammonia, and in nitric acid, HNO_3. Many animal substances also contain nitrogen.

Properties. *Physical.* Nitrogen is an odorless, colorless, and tasteless gas. Under a pressure of 27.5 atmospheres at a temperature of about $-149°C.$, it becomes a liquid. It is slightly lighter than air.

Chemical. The nitrogen molecule is regarded as being made up of two atoms. The molecules of nitrogen are very inert chemically, while the atoms are very active. (The student is advised to read over at this point the discussion of the nascent state). When the atoms of nitrogen are united with other atoms of nitrogen, they apparently have their chemical affinities satisfied, and hence, in its ordinary gaseous state nitrogen enters into chemical combination with very few substances. On the other hand, when the molecules of nitrogen are split up or when an atom of nitrogen is liberated from some compound containing nitrogen, the atom, at the moment of liberation, is very active and is capable of combining with a large number of substances.

Nitrogen will not burn, neither will it support combustion.

CARBON

Graphite—Charcoal—Diamond
SYMBOL, C ATOMIC WEIGHT, 12

Occurrence. Carbon is the essential constituent of animal and vegetable substances, the term *organic* being generally applied to the compounds of carbon which occur in the animal and vegetable kingdoms. Thus, meat, albumen, sugar, starch, wood, cellulose, coal, and petroleum are called organic substances. Many compounds of carbon found in nature may be produced synthetically; these are also termed organic. The term *inorganic* is used to designate compounds, such as rocks and the like, found in the mineral kingdom.

In many organic compounds, carbon occurs combined with hydrogen; methane, gasoline, kerosene, and turpentine are essentially compounds of carbon and hydrogen. In many other organic compounds it is combined with oxygen and nitrogen. Carbon also occurs in large quantities in combination with calcium, as limestone, marble and chalk; these compounds are, however, for convenience, spoken of as inorganic.

When heated, most organic compounds which exist in the solid state decompose, giving off certain volatile constituents, and finally leaving a black mass of impure carbon commonly known as charcoal.

> EXPERIMENT 6.—Apparatus required: Small hard glass tube (ignition tube); burner.
>
> Heat gradually a little sugar in the tube. Note the behavior of the sugar. Heat the black mass which remains to a red heat. Is it combustible?

Carbon also occurs in nature uncombined, as graphite (plumbago) and diamond. Graphite and diamond are regarded as crystalline carbon, while charcoal and similar forms of uncrystallized carbon are termed *amorphous*. It is hard to believe that graphite, charcoal, and diamond are one and the same element, and yet exhaustive tests show them to be only different forms of the element carbon.

Graphite. Graphite is found in nature in large quantities. It may be produced by heating a mixture of charcoal and iron to a very high temperature, the presence of the iron in some way aiding in the transformation. It is of a greyish, black color, soft and often shiny. Heated in the air, it remains practically unchanged, unless heated to a very high temperature, when it burns. It is insoluble in all known liquids.

Amorphous Carbon. Common forms of amorphous or non-crystalline carbon are ordinary charcoal, coke, coal, lampblack, gas-carbon, bone-black, or animal charcoal. These substances will be treated of more in detail later.

Diamond. This form of carbon exists in nature in many parts of the world. It can be made on a small scale by heating amorphous carbon under high pressure. It is brittle and extremely hard, and has a remarkable property of refracting light to which it owes its beauty and brilliancy when cut. In its purest form it is colorless, and its value depends to a large extent on its freedom from color except that the rarer stones showing a blue, red, or green shade are considered very valuable. It is chemically inert to all known liquids. When heated sufficiently it becomes black; it burns brilliantly when heated in oxygen.

THE ATMOSPHERE

Composition. Air is not a chemical compound, but a mechanical mixture of gases, and a very remarkable mixture owing to the fact that the two principal constituents, nitrogen and oxygen, are present in almost constant proportions. 1000 volumes of air usually contain 769.5 volumes of nitrogen and 206.5 volumes of oxygen, these proportions varying only slightly. The air also contains variable quantities of carbon dioxide, water vapor, hydrogen, ammonia, ozone (see page 76), elements of the *argon group, nitric acid, suspended mineral and organic matter. Sodium chloride is one of the mineral constituents. In and near large cities the air also contains compounds of sulphur, especially sulphur dioxide, SO_2.

The amount of moisture in the air, that is, its humidity, varies considerably at different times. The relative quantity of moisture which air is capable of taking up depends on the temperature. At 0°C. 1 cubic meter of air is capable of taking up about 4.8 grams of moisture; while at 30°C. it is capable of taking up about 30 grams of moisture. When air contains all the moisture it is capable of taking up at a given temperature, it is said to be saturated with moisture. When air, saturated with moisture at a given temperature, is cooled, the excess of moisture beyond the amount required to saturate the air at the temperature to which it is cooled, is deposited or precipitated.

Ammonia in the air is derived chiefly from the decomposition of organic matter containing nitrogen (nitrogenous organic matter).

Hydrogen is evolved by petroleum wells, and is also liberated during the decomposition of organic compounds.

Ozone (O_3) is usually present in the air in more appreciable quantities following thunder storms. Its presence is probably due to electrical conditions.

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*Argon group: these gaseous elements are present in the air in very small quantities, and are chemically inactive. They include argon, helium, neon, krypton and xenon.

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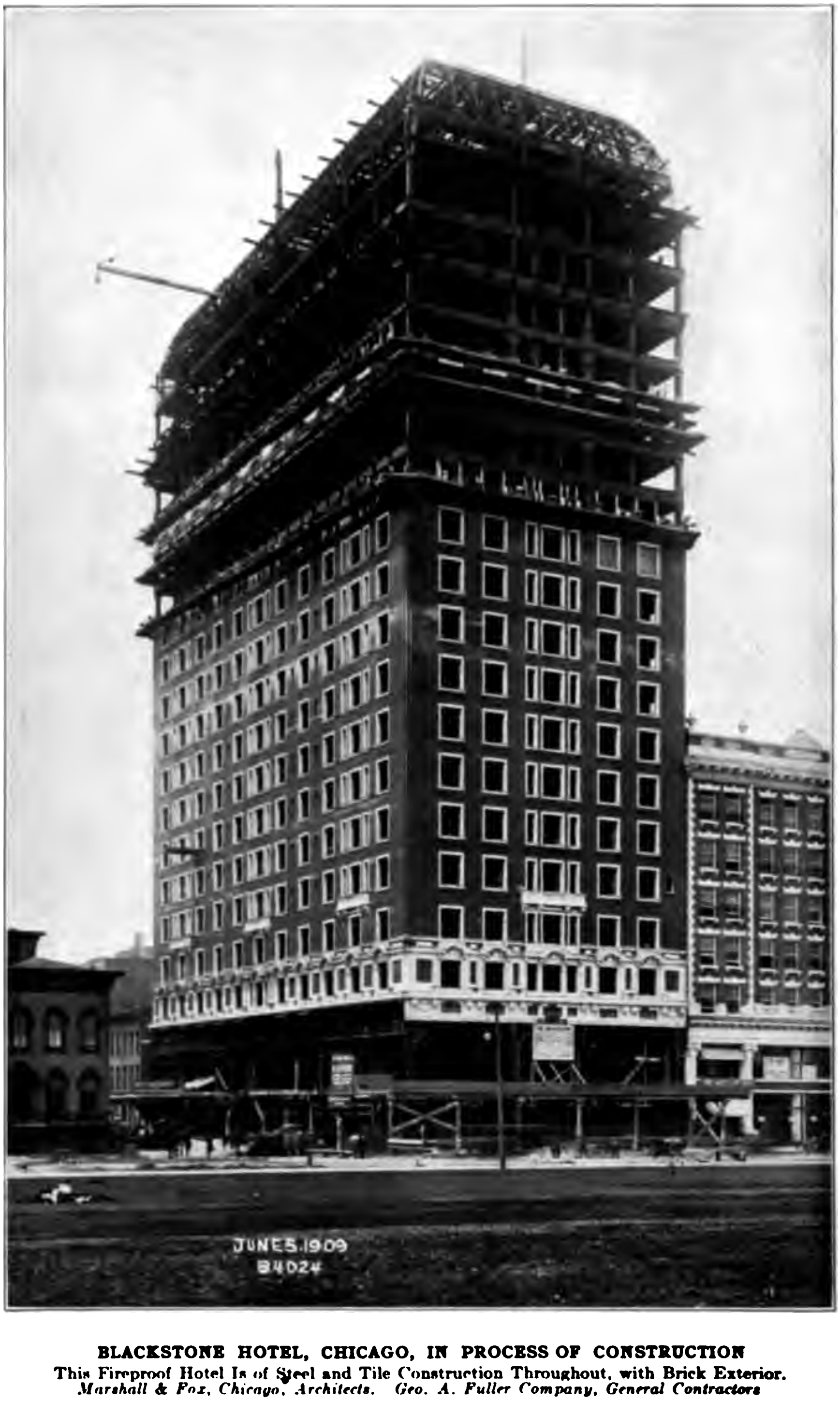
ASTOR, LENOX AND
TILDEN FOUNDATIONS



BLACKSTONE HOTEL, CHICAGO, IN PROCESS OF CONSTRUCTION
This Fireproof Hotel Is of Steel and Tile Construction Throughout, with Brick Exterior.
Marshall & Fox, Chicago, Architects. Geo. A. Fuller Company, General Contractors

Respiration, putrefaction, and combustion are processes continually supplying carbon dioxide. Plants and trees absorb it.

Supporter of Combustion. The oxygen of the atmosphere is necessary for the combustion of most substances, and is spoken of as the supporter of combustion. The supply of oxygen is apparently inexhaustible. When a combustible is burned in a confined volume of air, most of the oxygen in the latter is soon used up and the combustion ceases.

COMBUSTION

TEMPERATURE AND HEAT

We have already learned that chemical changes are accompanied by physical changes, and that physical changes are often accompanied by chemical changes. We come now to study certain heat changes which accompany chemical action. Every chemical action which takes place is attended by the evolution or absorption of heat, and when definite quantities of substances react, definite amounts of heat are evolved or absorbed.

It is important to distinguish clearly between *temperature* and *heat*. When one body is warmer or cooler than another body they are at different temperatures, and if these two bodies at different temperatures are brought together, heat flows from the warmer to the cooler body, and as a result one body becomes cooler and the other warmer; this continues until the bodies are at the same temperature. When a hot object is allowed to stand in the air, heat flows from the object to the surrounding air until the object is at the same temperature as the air. On the other hand when a body colder than the air is allowed to stand in the air, heat flows from the surrounding air to the body until equality of temperature obtains.

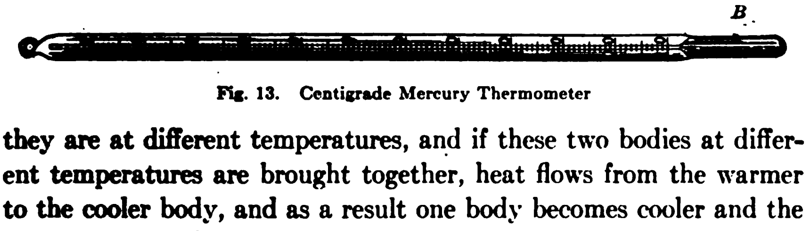


Fig. 13. Centigrade Mercury Thermometer

Thermometers. Temperature is usually measured by means of an instrument called a *thermometer*, Fig. 13, of which there are many different kinds. In its most common form it consists essentially of a glass tube closed at one end and terminating at the other end in a glass bulb, *B*, containing mercury. When the mercury is heated it expands and consequently rises in the tube; when cooled the mercury contracts and falls. A scale is used to measure the rise and fall of the mercury in the tube. Two scales are in general use, the centigrade and Fahrenheit. The centigrade scale is usually used in making chemical and physical measurements. There are two fixed points, viz, 0° and 100°; 0° indicates the temperature at which water freezes, and 100° the temperature at which water boils under standard atmospheric pressure. The difference in temperature between these two fixed points is constant, and the interval is divided into equal parts, called degrees. The scale may be extended beyond these points.

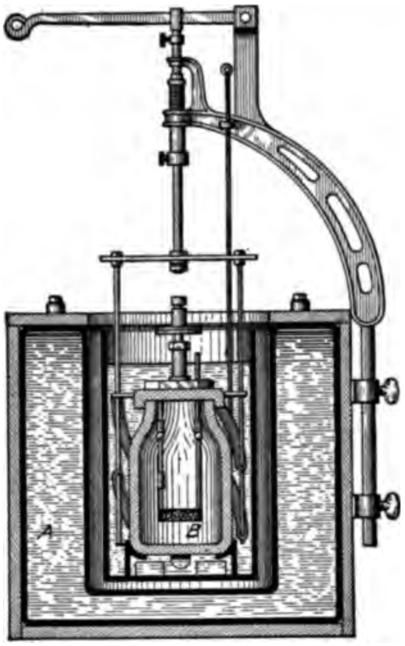


Fig. 14. Combustion Calorimeter

The measure of the change in temperature which a body undergoes when heated or cooled is not a measure of the quantity of heat which the body loses or gains. A liter (1000 cubic centimeters) of water, for example, requires a greater quantity of heat to raise its temperature by a given amount than does a half liter (500 cubic centimeters). A liter of hot water in one vessel may be at exactly the same temperature as a half liter of water in a similar vessel, yet the larger quantity of water contains twice as much heat. The thermometer, therefore, does not indicate the amount of heat.

High temperatures are often measured by means of a pyrometer, an instrument which is described in works on heat measurements.

In order to measure quantity or amount of heat, an instrument called a *calorimeter*, Fig. 14, is used. The ordinary form of calorimeter consists essentially of an inner chamber or bomb, *B*, surrounded by water, *A*, and so constructed that when a chemical reaction is allowed to take place in the chamber, the heat evolved is absorbed by the water without material loss. The weight of the water heated, and the rise in temperature which it undergoes, give data from which the quantity of heat evolved in the vessel may be determined.

Calorie. The unit generally used in heat measurements is the quantity of heat necessary to raise a gram of water 1° C. (0° to 1°) in temperature. This unit is called the *calorie*. Sometimes a larger unit is used, viz, the quantity of heat required to raise the temperature of 1000 grams (one kilogram) of water 1° C. This is called the large calorie, which is written with a capital (Calorie) to distinguish it from the small calorie—written calorie. Thus, 100 Calories is 1000 times as great as 100 calories. The statement that the quantity of heat evolved in any chemical reaction is 100 calories, means that the quantity of heat evolved is sufficient to raise the temperature of 100 grams of water 1° C. (0° to 1°C.)

Specific Heat. It requires different amounts of heat to raise equal quantities of different substances through the same range of temperature. Thus, it requires a great deal more heat to raise the temperature of a given weight of water by a certain amount than it does to raise the temperature of an equal weight of turpentine by the same amount. In fact, it requires a greater quantity of heat to raise the temperature of a given weight of water 1° C. (0° to 1°) than it does to raise an equal weight of any known substance through 1° C. In other words, the thermal capacity (heat capacity) of water is greater than that of any other substance. For this reason water is chosen as the standard of comparison; and the amount of heat

TABLE III

Specific Heats

Substance	Specific Heat
Water	1.000
Alcohol	0.620
Carbon disulphide	0.245
Ether	0.516
Glycerine	0.555
Turpentine	0.426
Aluminum	0.214
Copper	0.095
Calcium Chloride	0.164
Glass	0.198
Iron	0.112
Lead	0.031
Sodium Chloride	0.214
Tin	0.056
Zinc	0.095

required to raise the temperature of a given weight of any substance 1° (0° to 1°) as compared with the quantity of heat required to raise the temperature of an equal weight of water 1° C., is called the *specific heat* of that substance. The specific heat of water is, of course, taken as unity, and the specific heat of any substance is, therefore, less than unity. Thus, the specific heat of mercury is $\frac{1}{30}$ that of water, in decimals .033, because it requires thirty times as much heat to raise the temperature of one gram of water 1°C. (0° to 1°C.) as it does to raise the temperature of one gram of mercury 1°C.

Table III gives the approximate specific heats of a number of important substances:

OXIDATION

We have learned that when different substances are brought together they may remain associated together without undergoing any change in composition; that is, in the form of a mechanical mixture; on the other hand, when brought together, the atoms of one substance may enter into chemical union with the atoms of another substance, resulting in the formation of new molecules differing from those of either of the original substances. Whether or not chemical union will occur when the substances are brought together will depend upon the conditions and upon the chemical affinities of the substances. Many substances all around us, for instance, are in contact with the oxygen of the air; some of these have a strong chemical affinity for oxygen, but the affinity does not operate under the prevailing conditions. If sufficient heat is applied, however, the conditions are then proper for chemical action and some of these substances will enter into union with the oxygen; this union may take place rapidly, developing evident heat and light, or it may take place slowly, according to the nature of the substance and the conditions. In either case the reaction is termed *oxidation.* Oxidation, then, is a chemical reaction whereby oxygen unites with a substance. The term is also used in a broader sense by chemists to denote reactions similar in principle, but involving the addition to or extraction from a substance of certain elements other than oxygen. A discussion of such reactions does not come within the scope of this work, as we shall confine ourselves to the more common use of the term, viz, the direct union of a substance with oxygen.

Exothermic and Endothermic Reactions. Reactions accompanied by the evolution of heat are termed *exothermic reactions,* and the compounds formed by such reactions are termed *exothermic compounds.* Oxidation is an exothermic reaction, as it takes place with the evolution of heat. Thus, the rusting of iron and the burning of carbon, and the formation of carbon dioxide, are exothermic reactions.

On the other hand, compounds like carbon disulphide, in the formation of which heat is absorbed, are termed *endothermic compounds,* and the reactions by which they are produced are termed *endothermic reactions.* Consider the two reactions:

$$(1)\ C+O_2= CO_2+97000 \text{ cal. (exothermic)}$$
$$(2)\ C+S_2= CS_2-19600 \text{ cal. (endothermic)}$$

That is, 12 grams of carbon unite (1) with 32 grams of oxygen with the *evolution* of 97,000 calories of heat; (2) with 64 grams of sulphur with the *absorption* of 19,600 calories.

Rapid Oxidation. Oxidation is often a slow process—witness the rusting of iron, the oxidation of many other metals, and the

TABLE IV

Heats of Combustion

Substance	Heat in *calories* per 1 Gram
Acetylene	11527-11927
Alcohol ethyl (grain)	7184
Alcohol methyl (wood)	5330
Asphalt	9532
Benzene (coal tar product)	9650-10070
Carbon monoxide	5640
Coal	5000- 8000
Coke	7000- 8000
Charcoal	8080- 8137
Carbon disulphide	3244
Camphor	1413
Cotton Seed Oil	9500
Dynamite (75 per cent)	1290
Ether	9430
Glycerine	4316
Hydrogen	34460
Hydrogen sulphide	2741
Illuminating Gas	5200- 5500
Iron (to FeO)	1353
Magnesium	6007
Marsh Gas	13063-13344
Naphthalene	9354- 9690
Olive Oil	9328- 9800
Paraffin Oil	10340-11140
Petroleum	9600-11000
Phosphorus	5747
Sulphur	2241
Tallow	8370
Turpentine	10836
Wood	3990- 4422

decay of wood—so slow, in fact, that, although oxidation is an exothermic reaction and is accordingly accompanied by the evolution of heat, the heat flows to surrounding objects practically as fast as it is evolved. However, when the oxidation takes place rapidly, heat is evolved faster and a notable rise in the temperature of the substance occurs. When oxidation of a substance takes place with sufficient rapidity to develop both light and heat, it is termed *combustion*, and substances capable of undergoing rapid oxidation or combustion in the air are termed *combustibles* (see page 25). It is important to note in this connection that the term combustion sometimes receives a very general application, including slow oxidation, and, in general, all phenomena accompanied by the evolution of heat. The terms *burn* and *fire*, are, however, adequate for general application and it seems to be proper, correct, and very convenient to restrict the use of the term combustion, as is usually done, to processes of oxidation accompanied by the evolution of evident heat and light. Not all phenomena, therefore, which are accompanied by heat and light are combustion, for when a filament of carbon in a vacuum is heated to incandescence by passing an electric current through it, no combustion is said to occur as the glowing carbon undergoes no material chemical change.

Heat of Combustion. The heat evolved during the combustion or oxidation of a substance is termed the *heat of combustion*, and is expressed in calories or Calories (see page 35).

Table IV shows only approximate values of the heat of combustion for a number of substances. Owing to experimental difficulties involved in the determination, different observers have in many cases obtained quite different values for the same substance.

The quantity of heat developed in the oxidation of a given weight of any substance is *always the same* whether the oxidation takes place slowly or sufficiently rapidly to develop sensible light and heat; or whether the oxidation takes place in the air or in pure oxygen. The only difference between slow oxidation and rapid oxidation is in the length of time during which heat is evolved. In the former case, the heat gradually flows to surrounding objects and from them to other objects (often the air). When the oxidation takes place rapidly the total heat, being evolved in a short time, accumulates faster than it flows away, and the temperature of the body and its surroundings rises. It should be remembered in this connection that the evolution of light results from a high temperature and hence, when the oxidation is so rapid as to be accompanied by the emission of light (combustion), the temperature developed is comparatively high. Some substances evolve light at somewhat lower temperatures than others but in general the following classification applies:

Incipient red heat	about 500°C.
Low heat	700
Red heat	800
White heat	1300 to 1500 and above

Factors Influencing Combustion. Combustion is termed *slow* when the heat and light developed by the oxidation of the substance are feeble, and *active* when the heat and light developed are considerable. The rate of oxidation or combustion of any substance in the air depends upon (1) the chemical affinity of the substance for oxygen; (2) the heat of combustion; (3) the surrounding temperature; and (4) the physical condition of the substance, that is, whether it is in a finely-divided condition, in the form of vapor or in a compact, solid form.

(1) We have already seen that the affinity of a substance for oxygen may be strong, and yet at ordinary temperatures may not operate, requiring that the substance be heated sufficiently in the air before combustion takes place.

(2) In the case of the combustion of most substances, the rate of combustion is increased by a further rise in temperature, in other words, heat accelerates combustion. Hence, if the heat of combustion of a substance is high, the heat evolved during the combustion may accelerate the process, resulting in a still more rapid evolution of heat and still greater aid to the reaction.

(3) It is evident that the temperature of the surrounding air has an influence on the rate of combustion of a substance, for if the surrounding air is at a low temperature a greater quantity of the evolved heat will be absorbed or taken up in raising the temperature of the air, and as a result the temperature of the combustible will not become as high as it would in warmer air.

(4) When a substance is in a finely-divided condition, and especially when the particles are suspended in the air, as is the case of a substance floating in the form of dust or vapor, a relatively large amount of surface is exposed to the oxygen of the air and more of the material—that is, more of the molecules—can react with the oxygen of the air in a given time. For example, iron in a compact condition is capable of oxidizing slowly but is practically non-combustible; however, when very finely-divided iron (which has

been protected from oxidation) is thrown into the air, it burns brilliantly, producing a shower of sparks. Under such circumstances a large number of molecules of iron and oxygen are in contact at the same time, and as a result the oxidation of so many molecules at once raises the temperature of the particles of iron; this rise in temperature accelerates the oxidation which finally becomes so rapid as to cause evolution of light.

Combustion takes place much more rapidly in pure oxygen than in air, for in the latter case, each particle or molecule of oxygen is surrounded by about four particles of nitrogen and, therefore, for every particle of oxygen which strikes a burning substance in a given time about four particles of nitrogen strike it, and thus retard the combustion; the nitrogen also retards the process by taking up heat. A blast of air will, of course, tend to accelerate the combustion somewhat but as more nitrogen is also brought in contact with the object, this tends in a measure to prevent acceleration.

Calorific Intensity. Calorific intensity is the actual temperature of a burning substance. As we have seen, when a substance burns rapidly the evolved heat is distributed over a given amount of substance in a short time, the smaller the amount of a substance through which a given amount of heat is distributed the higher the temperature developed, in the absence of other factors capable of affecting the result. Hence, the temperature developed will depend upon the rate of combustion, the heat of combustion, and the conditions. In general, for substances in the same condition, the heat of combustion may be taken as a comparative indication of the calorific intensity. No standard method is in use for determining the calorific intensities of substances by direct experiment.

FLAME

Two gases or vapors at least are essential to the formation of flame; the gas or vapor burning, and the gas or vapor supporting the combustion. As the oxygen of the air is the supporter of combustion in all ordinary cases of burning gases or vapors, any single gas or vapor burning in the air gives rise to a flame. It will be evident from this that combustibles which are volatile, page 21, burn with the formation of flame because such substances are converted by heat into gases or vapors before combustion occurs.

Structure. The character and structure of flames vary considerably, depending upon the conditions and upon the nature of the burning gas or vapor. In general, the flames produced by the combustion of a gas issuing from a tube consist of several parts, which differ more or less from one another. The chemical reactions that take place in the different parts of the flame are exceedingly complex and in all cases have not thoroughly been traced.

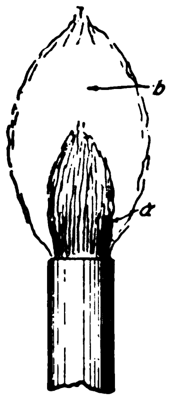


Fig. 15. Hydrogen Flame

The simplest form of flame consists essentially of an inner part or cone of unburned gases, surrounded by an envelope or sheath of burning gas. Such flames, for example, are produced by the combustion of carbon monoxide or hydrogen, issuing from a tube. Fig. 15 may be used to illustrate the general structure of the flame of hydrogen burning, in the air. *a* represents the inner part or cone which consists of unburned hydrogen, enveloped by the part *b*, which is burning hydrogen. The envelope or sheath *b* is in turn surrounded by an outer layer consisting of water vapor (not shown).

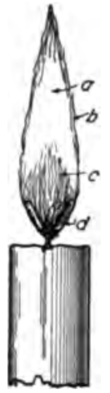


Fig. 16. Candle Flame

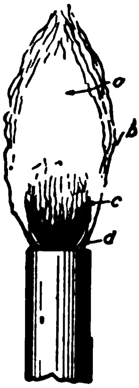


Fig. 17. Coal-Gas Flame

As the hydrogen issues from the orifice of the tube, that portion nearest the walls or circumference of the tube takes fire, passes upward, and is succeeded by more burning hydrogen; the oxygen of the air at these points is thus consumed (converted into H_2O vapor), and prevented from reaching the inner portion of hydrogen (cone).

A more complex form of flame is that produced by the combustion of hydrocarbons (see page 31) in the air. The flames from candles, coal gas, and oils, are produced by the combustion of hydrocarbons. In the case of the candle, the heat melts the wax which is then drawn up through the wick and finally converted into gas. These flames are essentially alike in structure, Fig. 16 representing the flame of a candle, and Fig. 17 representing a coal gas flame. In either figure *c* is the inner part, consisting of unburned gases. *d* represents a blue region at the base of the flames (practically free from unburned carbon). *a* represents an envelope of burning gas which is brightly luminous. This envelope is surrounded by an outer faintly luminous envelope, represented by *b*. The light-giving property of a flame depends upon the size and nature of this highly luminous part *a*, which with hydrocarbons is the largest part of the flame.

EXPERIMENT 7.—Apparatus required: Bunsen burner; a piece of glass tubing about 1 foot in length and about 1-8 inch internal diameter. This experiment serves to show that the inner cone or interior of a bunsen flame (see Fig. 19) consists of unburnt gases. Close the air holes at the base of the burner, Fig. 18, so that a luminous flame several inches high is produced. The glass tube is then held in the manner shown in the figure so that the lower end of the tube is in the interior of the flame (from ½ to 1 inch above the burner). The unburnt gases within the flame will ascend in the tube and may then be ignited at the upper end of the tube.

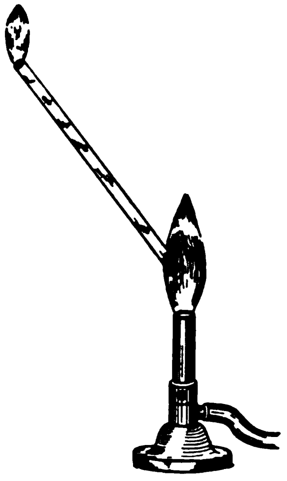


Fig. 18. Unburned Gas in a Flame

The structure of a flame from a match stick will, under ordinary conditions, be found similar in general strucure to the flame represented in Fig. 16. In considering flames in general, it is to be remembered that the structure depends not only on the nature of the burning gases or vapors, but also on the circumstances or conditions under which they are formed. In most cases coming under our every-day observation the outer envelope (usually thin) consisting of water vapor and other products of combustion can readily be distinguished. This envelope surrounds the main part of the flame. The interior may not contain a material quantity of unburnt gases if the flame is flat, or if the circumstances are such that ready admixture of the oxygen of the air with the interior is not prevented.

Luminosity. The principal causes of the luminosity or light-giving properties of a flame are: presence of solid particles, density of the burning gases, and the temperature.

The presence of solid particles operates so as to impart luminosity to flames owing to the fact that when the particles are heated to a high temperature they become strongly incandescent. For example, when the particles of a gas mantle are heated to incandescence, they emit light; in the same way most flames are made luminous by the presence of solid particles of carbon.

In general, *the more dense the gases or vapors* undergoing combustion the more luminous they are when heated to high temperatures. In the case of many flames, whether they contain solid particles or not, a rise in temperature increases the luminosity.

The luminosity of ordinary gas flames is principally due (1) to the presence of incandescent solid particles of carbon produced by decomposition of heated gases, and (2) to the presence of vapors or gases sufficiently dense to become luminous at the temperature of the flame. Smoky flames are produced by the escape of unburned particles of carbon, which may take place when there is insufficient oxygen present to burn the gas before decomposition of the hydro-carbons occurs.

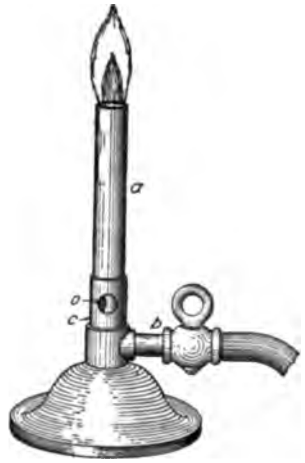


Fig. 19. Bunsen Burner

Bunsen Flame. When a certain mixture of coal gas and air is ignited it burns without separation of carbon, producing a faintly luminous flame. An apparatus for burning gas in this manner is called the *bunsen burner*, Fig. 19. The side-holes or apertures near the base of the burner may be opened or closed by turning a ring, which conforms to the curvature of the hollow base *c*, and

TABLE V

Temperature of Flames

Kind of Flame	Temperature in °C
Candles burning in the air	about 600- 900
*Sulphur burning in the air	about 1820
Alcohol burning in the air	about 1100-1200
†Hydrogen burning in the air	about 2024
†Carbon monoxide burning in the air	about 1997

*According to Von Schwartz. †According to Bunsen.

which is also provided with holes *o* corresponding to those in the base. The gas enters the burner at the base from a small jet within *c*, and rushes upward in the tube *a*. The result is a reduction of pressure within *c* and a consequent inrush of air through the side holes. The air and gas mix as they pass upward in the tube. This rapid upward motion of the mixture prevents the flame from passing down the tube when the mixture is ignited at the mouth of the burner. The air entering the side holes operates to reduce the luminosity of the flame by supplying sufficient oxygen to the flame to burn the gases before the decomposition and consequent separation of carbon takes place. The bunsen flame is free from soot and very hot.

Flame Temperature. The hottest part of the bunsen flame is about half-way between the bottom and the top where combination of gas and air takes place very rapidly. When the air holes are closed and the flame is luminous the hottest part of the bunsen flame has a temperature of about 1300°C. When the flame is produced with this burner by proper admixture of air the hottest part has a temperature of about 1500°C. The interior part of the flame, consisting of unburned gases, is comparatively cool although the tip of this part is rather hot. It must clearly be understood that the temperature of different parts of a flame produced by any kind of burner will vary with the conditions and with the construction of the burner.

Table V gives a general idea of the relative temperatures of different flames.

Incandescence — Combustion Without Flame. Most combustibles coming under our observation burn while in the form of gases or vapors, and the result is the formation of flame. What actually occurs when solid materials apparently undergo combustion with the formation of a flame, is that successive portions of the solid are converted into gases or vapors by heat and the combustion of the gases or vapors first formed heats another portion of the substance sufficiently to convert it into gas or vapor and so on. Combustible liquids are generally more readily converted into vapors by heat than are solid substances and as a rule are more inflammable.

Carbon in many forms under ordinary conditions, burns without the formation of flame but with the emission of light, incandescence, an action which is also sometimes called *smouldering*. The combustion of carbon may sometimes be accompanied by the formation of flame, owing to the fact that under certain conditions carbon burns to carbon monoxide which, of course, in turn burns in the air with the formation of flame. Any substance, as a rule, which is non-volatile at the temperature produced by its combustion burns with incandescence; iron and copper, for example, do not pass into vapor when burning in oxygen, and consequently form no flame.

A solid substance may burn with both incandescence and flame as is the case with partially burned wood; the portion converted by heat into gases and vapors burning with the formation of flame, and the charcoal, formed during the combustion, burning with incandescence.

IGNITION POINT

Definition. We have already learned that the chemical affinities for oxygen of many combustible substances do not operate at ordinary temperatures. In such cases mere contact with the air is not sufficient to cause active oxidation or combustion, but it requires the application of heat so as to raise the temperature of the combustible or a portion of it to a certain point before combustion will begin. If this were not so it is obvious that combustible substances when exposed to the oxygen of the air would take fire. Some substances require to be heated only a little before combustion begins while others require to be heated to a high temperature. The temperature to which a substance must be heated in the air in order for combustion to commence is called the *ignition point* or ignition temperature, or kindling temperature.* Every combustible substance has its own ignition point, and the ignition points of different combustibles vary between very wide limits.

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*Do not confuse ignition point with flashing point and fire test. (See pages 50 and 55.)

Influence on Combustion. *Spontaneous Ignition.* If the ignition point of a substance is below ordinary temperatures such a substance will evidently take fire when exposed to the air at ordinary temperatures. Such substances are said to be *spontaneously inflammable.* Other combustible substances whose ignition points are above ordinary temperatures ignite when exposed to the air, owing to the fact that they begin to oxidize comparatively rapidly at ordinary temperatures, and as a result the heat evolved by the oxidation causes a rise in temperature which in turn aids the further oxidation, and the process thus continues till the ignition point is reached then the substance takes fire. Such processes will be discussed more at length under spontaneous ignition.

EXPERIMENT 8.—Apparatus required: Ordinary iron spoon; burner; piece of glass, preferably a 2-inch watch glass; forceps.

Chemicals required: Two or three pieces of yellow phosphorus about the size of a pea (phosphorus is kept under water and must not be touched with the hands. It can be secured in small pieces. The student *should not attempt to cut it*): small quantity of sulphur; and a few small pieces of charcoal.

Place a small piece of the phosphorus by means of forceps on the glass and allow it to stand. Note its behavior. (It is desirable that the temperature of the room should be between 15°C. and 38°C.) Notice the fumes given off. The phosphorus undergoes oxidation when exposed to the air; the oxidation heats the phosphorus. The fumes given off are the products of oxidation, and consist of compounds of phosphorus and oxygen. Finally the phosphorus takes fire (if it is desired to stop the experiment cover the phosphorus with an inverted tumbler or cup).

Heat carefully a little of the sulphur in the spoon so as to secure a gradual rise in temperature. Try a similar experiment with charcoal. Observe that there is a marked difference in the temperatures at which these substances take fire, that is, enter into active combustion with the oxygen of the air.

In the above experiment, the phosphorus took fire very readily, requiring only a slight elevation in temperature to cause its combustion; this elevation in temperature was produced by the heat generated by the oxidation of the phosphorus. The sulphur required a higher temperature to cause combustion, and the charcoal still higher. The first condition, then, necessary to start the combustion of a combustible substance in the presence of air, is that a part of the combustible be at its ignition point, the requisite temperature having been obtained from a flame, spark, hot object, or spontaneous heating.

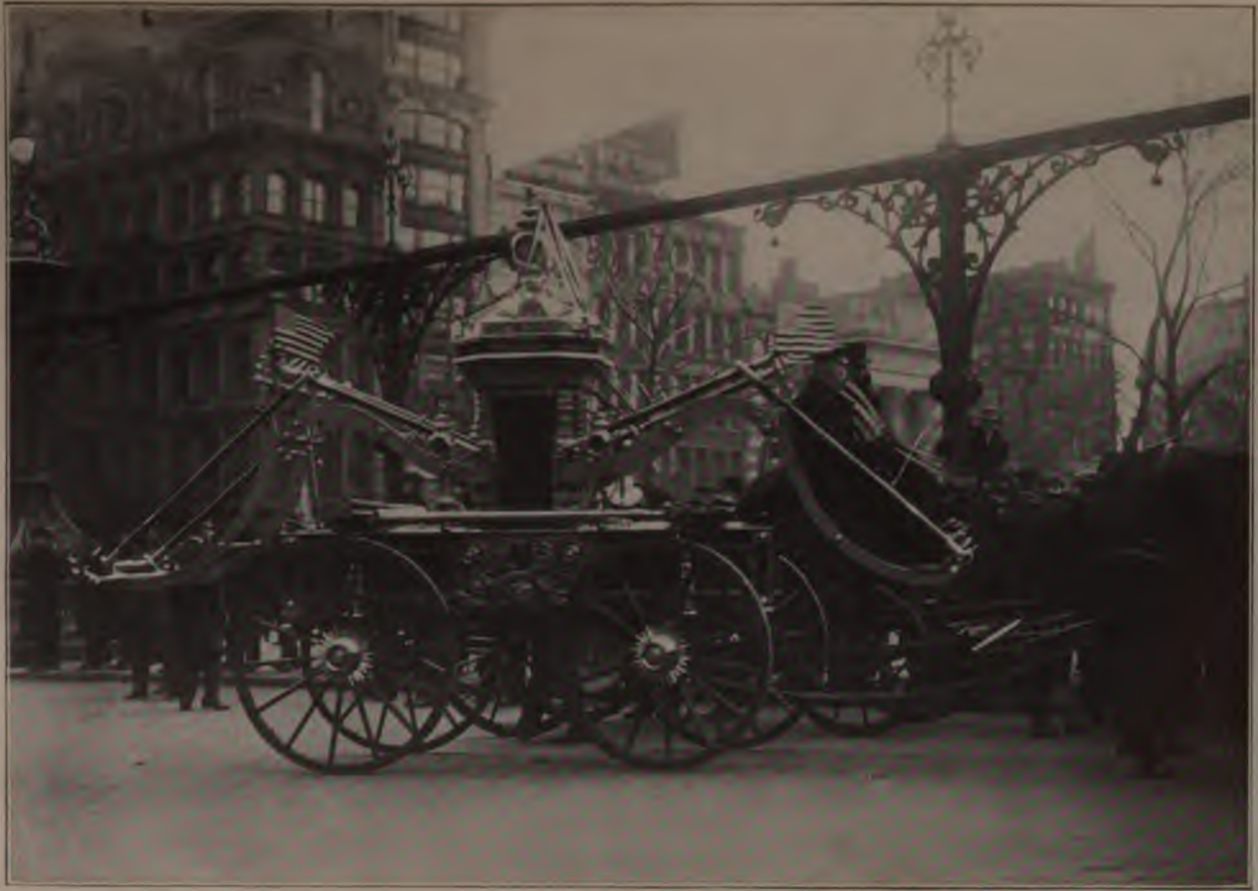
Combustion without Continuous External Heat. When the temperature produced by the combustion of a substance is higher than the ignition point of the substance, such a substance on being ignited will continue to burn, because the heat evolved by the combustion of the portion ignited heats the surrounding portion to or above the ignition point and the combustion thus propagates itself from particle to particle. All ordinary processes of combustion take place in this way.

Combustion only with Continuous External Heat. On the other hand, when the temperature produced by the combustion of a substance is lower than the ignition point of the substance, such a substance will not burn without the continuous application of external heat, because the moment the igniting source of heat is withdrawn, the heat evolved by the ignited portion becomes insufficient to raise the temperature of the surrounding portions to the ignition point, and the combustion ceases.

For example, if a portion of ammonia, NH_3, is heated in the presence of air to the ignition point of ammonia, the portion heated will burn, but as the heat evolved by the combustion which then occurs is not sufficient to maintain the ignition temperature of ammonia, the combustion of the ammonia ceases, as soon as the external source of heat is withdrawn. Another similar case is nitrogen, its ignition point in the air being higher than the temperature developed by its combustion in the atmosphere; if this were not true, a portion of the oxygen and nitrogen of the atmosphere might be ignited by a flash of lightning, and the combustion communicated from the ignited portion to other portions, resulting in the general combustion of the nitrogen of the air.

The prevention of the propagation of the combustion of a substance by effecting the cooling of a portion of the substance to a temperature below its ignition point may be shown by the following experiment.

EXPERIMENT 9.—Apparatus required: Bunsen burner; fine wire gauze about 4 inches square. Turn on the gas and immediately hold the gauze about 1 inch above the top of the burner, in the manner shown in Fig. 20, and apply a lighted match to the stream of



AN OLD-TIME MANUAL FIRE ENGINE

[illegible]

[illegible] AND
[illegible]

gas above the gauze. Note that the gas burns above the gauze, but that the combustion is not communicated to the gas below the gauze.

The gauze conducts away the heat evolved by the combustion of the gas so fast that the gas below the gauze does not become heated to its ignition temperature. If the temperature of the metal gauze is allowed to rise to the ignition point of the gas, the gas on the lower side of the gauze will take fire. In case the experiment is performed with hydrogen gas instead of coal gas, it will be found that as soon as the hydrogen on one side of the gauze is ignited, the combustion will be propagated through the gauze to the hydrogen on the other side, owing to the fact that in case of hydrogen the gauze soon becomes heated to the ignition point of hydrogen. It will also be observed that the ignition point of hydrogen is lower than the ignition point of coal gas.

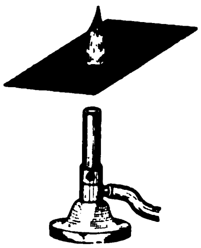


Fig. 20. Principle of Safety Lamp

This is the principle on which many safety lamps and appliances, making use of wire gauzes, depend to prevent the propagation of combustion of gases.

Apparent Lowering of Ignition Point. The condition of a combustible when exposed to the air apparently affects the temperature of ignition; thus, when very finely-divided iron (see page 41) is exposed to the air at ordinary temperatures under certain conditions, it ignites. In fact, under certain conditions many combustibles ignite at temperatures which are apparently below their ignition points, but this lowering is only apparent. Fineness of division of

TABLE VI

Ignition Point

Substance	Temperature °C
Phosphorus	60
Carbon disulphide vapor	150
Sulphur	250
Acetylene	480
Hydrogen	612
Marsh Gas	656
Coal Gas	645
Charcoal	350 to 700*

*Depending on the nature of the wood and temperature at which it was charred.

a substance favors intimate contact with the oxygen of the air, and the large amount of surface of the material in intimate contact with oxygen of the air presents conditions which allow a relatively large number of molecules of the substance to oxidize at the same time, and thus produce heat fast enough to raise the body to incandescence. When the iron is in the compact state, however, the heat of oxidation is dissipated about as fast as it is generated.

The ignition points as obtained by experiment depend not only on the nature of the substance, but also in a measure on the conditions, such as the humidity of the air, pressure, nature of the vessel in which the experiment is conducted. The ignition points stated in Table VI are, therefore, approximations, the figures applying to the substances when under conditions approaching those met with in practice.

FLASHING POINT AND FIRE TEST

FLASHING POINT

Definition. The *flashing point*—also called flash point and flash test—of a substance is the lowest temperature at which it gives off vapor sufficiently rapidly to form with the surrounding air a mixture* which is capable of burning when ignited.

Liquids. The flashing point for a liquid may be determined in the following manner:

EXPERIMENT 10.—Apparatus required: Porcelain dish (deep form), diameter about 75 m.m., capacity about 75 c.c.; cover for dish; support for dish; thermometer; burner.

Chemicals required: About 100 c.c. of kerosene.

Pour sufficient kerosene into the dish to fill it within about 20 m.m. of the top. Place the bulb of the thermometer in the kerosene and note the temperature. Hold a lighted match so that the flame is about midway between the surface of the kerosene and the top of the dish. Note that the air above the kerosene does not contain sufficient inflammable vapor to form a combustible mixture for no flame is produced by the application of the lighted match. (Some low grade kerosene flashes at ordinary temperatures, but fairly good kerosene should not flash under the conditions of this experiment at a temperature below 40°C. or 104°F.)

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*Inflammable vapor-air mixtures are discussed, pages 68 and 69.

Now light the burner, and adjust the flame (by regulating the supply of gas in case a gas flame is used) so that it is very small—say about $\frac{1}{2}$ inch in height—and place under the dish of kerosene. Heat the kerosene as gradually as practical, noting the temperature about every half-minute, and applying a match flame for an instant near the center of the dish half-way between the surface of the kerosene and the top of the dish. Do not hold the match flame near enough to the kerosene to heat it. If it is desired, the thermometer may be supported as shown in illustration, Fig. 21. Finally the temperature of the kerosene will become high enough to cause sufficient evaporation from the heated kerosene in a given time to form with the air above the surface of the kerosene a gaseous mixture, which will take fire when ignited. Unless the kerosene has been heated several degrees above its flashing point, the combustion will cease as soon as the ignited mixture of vapor and air has burned. The flash may after a moment be made to occur again. Continue the heating, and finally it will be found that on applying the match flame, the kerosene *apparently* takes fire and burns continuously. Extinguish the combustion by placing the cover on the dish. What actually burns when the kerosene *apparently burns* continuously, is the kerosene *vapor*. When the momentary flash occurred the rate of evaporation of the kerosene was not sufficiently rapid to supply vapor as fast as it burned in the air, hence as soon as the accumulated vapor burned the combustion ceased. Finally, a temperature was reached at which the vapor was given off as fast as it burned, and as a result the combustion when started continued; this is the *fire test* of the kerosene, as will be seen later.

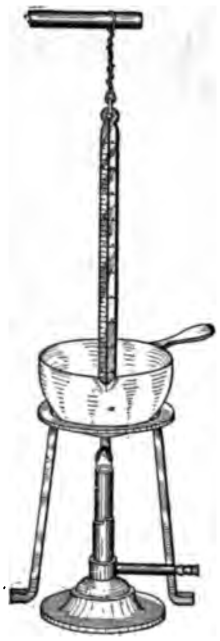

Fig. 21. Determination of Flashing Point

Commercial Test Methods. The flashing point of a liquid may more accurately be determined by means of an apparatus especially constructed for the purpose called a Flashing Point Tester or simply a Tester. One of the best forms is known as the "New York State Board of Health Tester." It was devised by the Michigan State Board of Health in 1873, and modified, Fig. 22, by Dr. A. H. Elliott. It consists essentially of an oil cup *A*, usually made of copper and capable of holding about 296 c.c. of oil or other liquid. The upper part *a* of the cup has a larger diameter than the lower part, in order to provide a chamber, termed the explosion chamber. The cup is also provided with a glass cover *C*, carrying a thermometer *B* for observing the temperature of the liquid in the cup. The glass cover is provided with an aperture *O* for insertion of the testing flame, usually consisting of a small gas jet one-quarter of an inch in length, shown at *T*. *D* represents the water bath which is supported by the stand *S*.

The following directions for conducting the test with this form of apparatus were reported by the New York State Board of Health (1882).

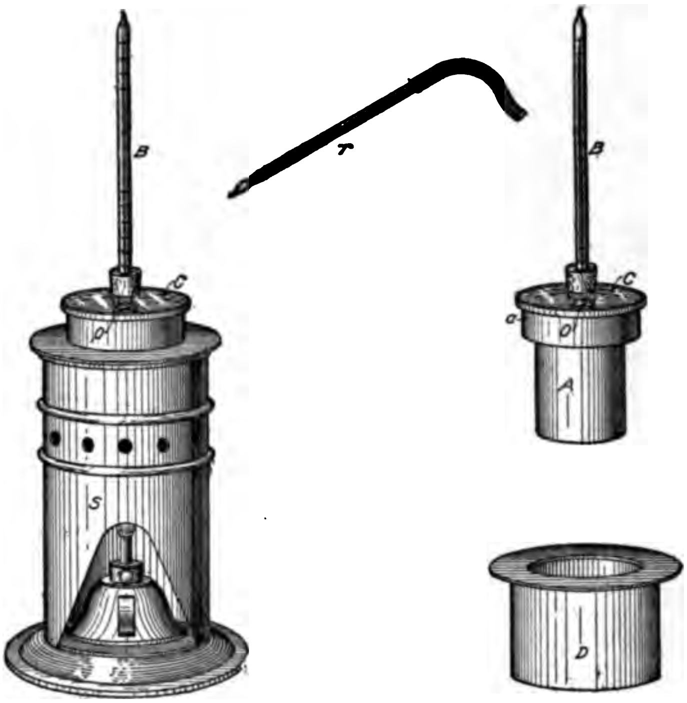

Fig. 22. Flashing Point Tester

"Remove the oil cup and fill the water bath with cold water up to the mark on the inside. Replace the oil cup and pour in enough oil to fill it to within one-eighth of an inch of the flange joining the cup and the vapor-chamber above. Care must be taken that the oil does not flow over the flange. Remove all air-bubbles with a piece of dry paper. Place the glass cover on the oil cup, and so adjust the thermometer that its bulb shall be just covered by the oil.

"If an alcohol lamp be employed for heating the water bath, the wick should be carefully trimmed and adjusted to a small flame. A small bunsen burner may be used in place of the lamp. The rate of heating should be about two degrees per minute, and should in no case exceed three degrees.

"As a flash torch, a small gas jet one-quarter of an inch in length, should be employed. . . . . .

"When the temperature of the oil has reached 85°F., the testing should commence.* To this end insert the torch into the opening in the cover, passing it in at such an angle as to well clear the cover, and to a distance about half-way between the oil and the cover. The motion should be steady and uniform, rapid and without any pause. This should be repeated at every two degrees rise of the thermometer until the thermometer has reached 95°, when the lamp should be removed and the testings should be made for each degree of temperature until 100° is reached. After this the lamp may be replaced if necessary and the testings continued for each two degrees.

"The appearance of a slight bluish flame shows that the flashing point has been reached.

"In every case note the temperature of the oil before introducing the torch. The flame of the torch must not come in contact with the oil. . . . ."

There are various forms of testers in use, and there are many different methods followed in making the test. The results obtained will vary with:

(1) *The dimensions of the cup.* If the diameter of the cup is large, more surface of the liquid is exposed to the air, and as a result the faster the evaporation at a given temperature; hence, the air above the liquid is charged with vapor sooner than if the evaporation were slower and consequently, the flashing point is lower.

(2) *Rate of heating.* The faster the liquid is heated, that is, the higher its temperature is made to rise in a given time, the more vapor is given off in a given time; hence, the lower the flashing point.

(3) *The quantity of the liquid heated.* The greater the amount of liquid heated the more vapor is driven off in a given time, hence the lower is the flashing point.

(4) *Testing flame.* A large testing flame may heat the surface of the liquid above the temperature of the liquid, and thus cause a flash to occur before the true flashing point is reached. The vapor and air are more completely mixed at the edges of the explosion chamber, hence, if the testing flame is applied only at the center of the cup the results obtained may be too high.

Other conditions may affect the results, but the above are the principal ones to have in mind in comparing results. It is evident from these considerations that in specifying the flashing points of different substances, it is highly desirable to designate the particular form of apparatus used, and the definite method of making the test.

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*This will depend on the nature of the liquid; testing should commence at a lower temperature in certain cases.

The form of apparatus described above, and the directions for making a test with it, are used to a large extent in this country. Some observers make the test with the cover off of the cup; results obtained in this way are higher than would be obtained under similar conditions in a covered cup, owing to the fact that when the cover is off more vapor is carried away from the explosion chamber by the air. Apparatus having cups without covers are called open-cup testers or simply *open testers*, while those provided with covers are called *covered testers* and results are often reported as *open* or *closed cup*.

Special Test Methods. Some modifications in the apparatus described above and in the directions for using it are necessary in obtaining the flashing points of liquids which flash at unusually low or high temperatures. In order, for example, to determine the flashing point of a liquid which flashes below ordinary temperatures it is necessary to cool the liquid. Thus, gasoline, as generally found on the market today, flashes at about −20°C., hence it is evidently necessary to cool the gasoline below this temperature in order to determine its flashing point.

The water bath cannot be used in determining the flashing points of liquids which flash at high temperatures, as water cannot be heated above 100°C. at atmospheric pressure. The most satisfactory way of determining the flashing points of such liquids is to heat the cup containing the oil directly over the burner. In this case, however, the heating must be conducted very carefully, the rate of heating being about 8° per minute.

Solids. Most combustible solids, as we have learned, burn wholly, or in part, in the form of vapor or gas; that is to say, all or most of the solid is changed to the gaseous state by heat before combustion occurs. Hence, the flashing point of a solid as in the case of a liquid is the lowest temperature at which it gives off sufficient vapor to form readily a combustible mixture with the surrounding air. The results will, of course, vary considerably with the conditions.

FIRE TEST

The fire test, also called the *burning point,** of a liquid may be defined as the lowest temperature at which the liquid gives off vapor sufficiently rapidly to form *continuously* with the surrounding air a mixture which is capable of being ignited. In other words, when a liquid is heated to its *fire test* or so-called burning point, it gives off vapor as rapidly as the vapor burns. Thus, in Experiment 10, when the kerosene reached its fire test and was ignited, it burned continuously. It is evident, then, that in the case of kerosene, vapor is given off faster at the fire test than at the flashing point. The fire test is, in general, higher than the flashing point, though in the case of ether,. carbon disulphide, benzol, alcohol, and many other liquids the flashing point and fire test coincide.

The fire test is determined in most cases by continuing to heat the liquid in an open cup after the flash test is made until the temperature is reached at which the liquid itself apparently burns, page 51, when the testing flame is applied so as to secure ignition. The flashing point and fire test indicate to a large extent in many cases the relative combustibility of liquids. (See page 77.) Thus, from Table VII, the flashing point of gasoline is about −20°C. and the flashing point of certain grades of paraffin oil is about 220°C. From this it is known that gasoline readily gives off vapors which will burn in the air, even though the gasoline is at a temperature considerably below ordinary room temperatures; the presence of gasoline, therefore, in a room at ordinary temperatures may cause a fire, if a flame is brought near the gasoline. On the other hand, it is known from the flashing point of paraffin oil that the vapors are not given off in material quantity at ordinary temperatures, and paraffin oil is not, therefore, liable to be ignited by a lighted match, unless the oil is heated accidentally.

SPONTANEOUS IGNITION

We have learned that in order for a combustible substance to take fire in the air, it is necessary that a portion of the substance be heated to its ignition point. In most cases of combustion coming under our observation, the substance was heated to its ignition point

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*The burning point should not be confused with the ignition point.

TABLE VII

Flashing Point and Fire Test

SUBSTANCE	FLASHING POINT ° C. (Closed Cup)	FIRE TEST °C.
Acetone	2	2
Alcohol (ethyl) grain, Absolute	12	12
Alcohol (ethyl) grain, 95.90 per cent	16	16
Alcohol (methyl) wood*	10	10
Alcohol (methyl) U. S. Approved for denaturing	−6	−6
Alcohol denatured†	13	13
Amyl Acetate	21	
Aniline	76	
Benzene (Benzol)	−8	−8
Benzine (Sp. gr. .8805)	4	10
Camphor oils	55	
Carbon disulphide	−34‡	−34‡
Collodion	4.4**	
Columbian Spirits	7	
Cologne*	15–16	
Cotton Seed Oil	305	340
Corn Oil	249	335
Creosote Oil (Coal tar Product)	75–115	80–124
Ether, Petroleum	−18**	−18**
Ether	−34‡	−34‡
Ethyl Acetate	4–5	
Gasoline*	−20	−18
Lacquer (shellac)	4–21	
Linseed Oil (Raw)	274	340
Linseed Oil (Boiled)	192	300
Olive Oil	233	283
Petroleum Naphtha	−18**	−18**
Petroleum (Crude)*	−15	− 7
Paraffin Oil	210–228	246–260
Pyridine* (fairly pure)	19	19
Toluyl Toluene	13	
Turpentine*	36	46
Xylol (Xylene)*	27	49

*Flashing point and fire test may vary with sample. †"Completely denatured." Flashing point of denatured alcohol varies with the composition. ‡Approximate. **At or below.

by the application of external heat. However, under certain conditions the ignition of some substances occurs without the application of sufficient *external heat* to raise the temperature of the substance to its ignition point. What actually occurs in such cases is that the substance, through physical or chemical changes taking place within the substance itself, becomes heated to its ignition point, a process termed *spontaneous ignition*—often incorrectly called spontaneous combustion. This self-heating of a substance is termed *spontaneous heating* and evidently precedes spontaneous ignition.* (See Experiment 8, page 47.)

In some cases, the spontaneous heating is produced by physical changes which are accompanied by the evolution of heat, as for example, the absorption of gases or vapors by charcoal. In other cases, the heating is produced by chemical reactions (usually oxidation) taking place between the constituents of the substance or between the substance and the oxygen of the air.

Classification of Substances. There exists no basis for a well-defined and comprehensive classification of the different processes of spontaneous heating which are liable to result in spontaneous ignition. The following discussion covers the principles involved in certain processes and the phenomenon in each case is characteristic, but it must be understood that certain of the conditions favoring the spontaneous ignition of substances vary according to the nature of the material and of the surroundings.

General Considerations. Most of the cases of spontaneous heating which are met with in practice and which are liable to result in spontaneous ignition are caused by oxidation. It will be remembered that the oxidation of many substances is a slow process at the start, and, consequently, unless they are under conditions favorable to the accumulation of the evolved heat, their oxidation may not result in a material rise in the temperature of the substance. On the other hand, when the oxidation occurs under favorable conditions a rise in temperature occurs, and this stimulates the process, resulting finally in ignition. General conditions which favor the accumulation of heat are, freedom from drafts which might carry away heat, warm surroundings, and the amassing of material so that the heat is not readily conducted away.

It is already evident from what has been said that the addition of external heat in many cases favors spontaneous heating. In some cases this outside agency is necessary in order to start the reaction, which once started may continue without further aid. In most cases of spontaneous heating by oxidation, it is required that there be a free supply of oxygen of the air. The pressure of moisture is often necessary and generally favors the process.

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*Possible exception in certain cases where sudden decomposition is produced by detonation or shock.

Oxidizing Oils. Many vegetable and animal oils, when disseminated over a large surface—as for example, when fibers, rags, cotton waste, sawdust, and porous organic matter, are impregnated to a greater or less extent with oil—react with oxygen from the air, the process being one of oxidation; if the conditions are such that the heat produced by the oxidation is not dissipated as fast as it is produced, the temperature of the oiled mass rises, and as a result spontaneous ignition may occur if the process is allowed to continue.

Linseed oil is the most dangerous of the class in this respect, and cotton seed oil is probably next in order. Other oils which are considered liable to cause spontaneous ignition in a similar way are: rape, olive, palm, and cocoanut oils. Some of the animal substances that are subject to oxidation, and which may cause spontaneous ignition, are: codliver and seal oils; goose, bone, and hog fats. Rancid fats are able to combine readily with oxygen and should be regarded as liable to produce spontaneous ignition. The admixture of oxidizing oils with substances which absorb oxygen (used in certain varnishes and generally termed *driers*) increases the hazard.

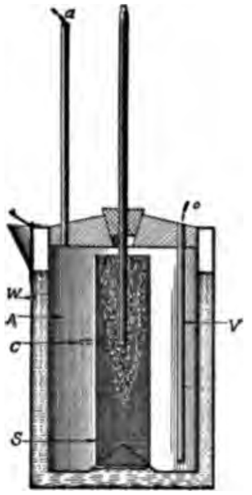

Fig. 23. Determination of Spontaneous Heating

The tendency of oxidizing oils toward spontaneous heating when spread on cotton can be studied by means of an apparatus shown in Fig. 23. It consists essentially of a wire gauze cylinder *S* which is surrounded by double-jacketed copper water bath *W*, provided with a tight-fitting lid, thermometer, and air tubes *V* and *a*. To test an oil, fourteen grams of it are evenly distributed over seven grams of cotton waste. The oiled cotton is then placed in the cylinder inside of the water bath, a thermometer inserted in the cotton, and the bath heated until the water reaches the boiling point. A temperature of 100°C. tends to hasten oxidation of the oil and thus to develop any tendency of the oiled mass to heat spontaneously, which may be observed by taking frequent readings of the thermometer.

Some of the results of tests obtained with certain oils are shown in Table VIII:

TABLE VIII

Spontaneous Heating

Oils	Temperature °C	Time, Minutes
*Linseed	234	65
Cotton Seed	234	70
Olive	234	130

*These results by Dr. A. H. Gill.

Rags and waste containing oxidizing oils have caused many fires, and are to be regarded as hazardous. Lampblack and sawdust when mixed with oxidizing oils are liable to spontaneous ignition.

As is well known mineral oils are not oxidizing and are not liable to cause spontaneous ignition in this way.

Agricultural Products. Hay, fodder, and bran, when piled in heaps, are capable in the presence of air and moisture of undergoing chemical change with the production of heat, which under favorable conditions may raise the temperature of the mass to the ignition point. In most cases of spontaneous ignition of agricultural products, the first stage of the spontaneous heating is essentially one of fermentation. The materials may become heated to a marked extent during this process, and finally may become charred and ignited. The changes may be arrested or accelerated before the ignition point is reached by various causes which favor the dissipation or accumulation of heat.

Charcoal. There are various kinds of charcoal, all varieties, being essentially carbon; wood charcoal is the most important variety. Charcoal contains innumerable pores, and possesses such an affinity for certain gases and vapors, that it is capable of absorbing many times its own volume of these gases. In the case of hot, newly-made charcoal, its pores are empty and, when exposed to the air, the absorption of gases takes place, accompanied by the production of heat. This process often raises the temperature of the charcoal to its ignition point. In general any process which may drive out the absorbed gases, and leave the pores empty, may thus indirectly cause the spontaneous ignition of the charcoal, as, for example, the heating of moist charcoal. As the temperature of ignition of charcoal is influenced by the temperature at which the carbonization or charring of the wood occurred, the charcoal produced by heating wood at low temperatures is more liable to spontaneous ignition by spontaneous heating than charcoal in general. This explains the danger of having hot steam pipes in contact with woodwork, etc.

Owing to the diversified nature of many processes which may cause spontaneous ignition under various circumstances it is out of the question to enter into an extended treatment of the subject within the scope of this text. It is well to remember that the processes of spontaneous ignition generally met with in practice consist essentially of oxidation. Certain products liable to ignite spontaneously are discussed later.

PRODUCTS OF COMBUSTION

We have seen that, when a substance undergoes combustion in the air, the process is one of oxidation. As carbon is an essential constituent of most combustible substances, and as carbon burns in a free supply of air forming carbon dioxide, the latter is one of the most common products of combustion.

Carbon Dioxide.

FORMULA, CO_2	DENSITY, 21.9 (H = 1) or
MOLECULAR WEIGHT, 43.9	1.529 (air = 1)

Carbon dioxide is also often called *carbonic acid*, *carbonic acid gas*, and *carbonic anhydride*. It is a heavy colorless gas about one and a half times as heavy as air. It has a faint acid taste and a slight pungent odor. It liquefies at 17°C. under a pressure of about 54 atmospheres (800 pounds to the square inch). Liquid carbon dioxide is a colorless liquid with a boiling point about —80°C.

The gas does not support respiration and acts injuriously on the system; air containing about 12 per cent of carbon dioxide by volume is capable of causing suffocation. It does not support combustion but apparently retards it. (See page 64.)

Carbon dioxide is readily produced by heating sodium bicarbonate, when the following reaction takes place

$$\underset{\left[\substack{2\,(1+23+12+48)\\168}\right]}{2\,HNa\,CO_3} = Na_2\,CO_3 + H_2O + \underset{\left[\substack{(12+32)\\44}\right]}{CO_2}$$

In other words 168 grams of sodium bicarbonate are capable of liberating 44 grams of carbon dioxide—about 22.4 liters, measured at standard temperatures and pressure.

Carbon Monoxide

FORMULA, CO MOLECULAR WEIGHT, 28
DENSITY, 14 (H = 1); .967 (air = 1)

When many substances undergo combustion in an insufficient supply of air (oxygen) the carbon is burned to carbon dioxide and carbon monoxide. Carbon monoxide is a colorless and tasteless gas, having a faint odor. It is combustible, burning, when ignited, to carbon dioxide, with a pale-blue flame. It forms explosive mixtures with air, and is often present in the air after a dust explosion. (See page 72.) It is a very poisonous gas, and should not be inhaled as it causes insensibility and often death when taken into the lungs in material quantity.

Other Products of Combustion. *Water* is a common product of the combustion of most substances.

An important product of the combustion of many compounds containing sulphur is *sulphur dioxide,* which has a very pungent, irritating odor, and when the conditions are right for its formation at a fire, it is capable of retarding men in the work of extinction to a marked extent. It is formed, for example, when carbon disulphide burns in the air,

$$CS_2 + 3O_2 = 2SO_2 + CO_2$$

The inert constituents of the air, of which *nitrogen* and *carbon* are the most conspicuous examples, are also found mixed with the products of combustion of substances. Unburned carbon or soot hardly requires to be discussed in this connection.

EXTINCTION OF COMBUSTION

In order for the combustion of a substance to occur, it must possess a chemical affinity for oxygen; it must be at a temperature at which this affinity operates (ignition point); its heat of combustion must be at least sufficient to maintain the ignition temperature; and a supply of air must be present (supporter of combustion).

Methods. It follows, therefore, that the process of combustion may be retarded or arrested (1) by the presence of any substance which affects adversely the affinity of the combustible for oxygen; (2) by cooling the combustible or surrounding air or both; (3) by excluding or diminishing the supply of air (oxygen).

Method (1) has never been applied successfully in practice. Method (2) is usually carried out by the application of water. In special cases certain other liquids may be used, also sand, etc. Method (3) is obviously carried out by the application of gases or of certain substances which are capable of generating gases. The application of water not only has a cooling effect, but in a measure serves to exclude air.

Water. *Advantages.* In general, water is the most efficient agent for cooling burning materials, owing to its great thermal capacity (specific heat—see page 35). Moreover, a great deal of heat is required to convert water into steam (latent heat), after the temperature of water has reached 100°C. Taking both of these factors into consideration, it is estimated that a given weight of water will take up more heat and consequently have a greater cooling effect when applied to an ordinary fire than an equal weight of any substance known to be available for such use.

Water also serves in a measure to retard combustion to a small extent by diminishing the supply of air, owing to the fact that the steam formed dilutes the air in contact with the combustible, and thus reduces the number of molecules of oxygen of the air which come into contact with the burning substance in a given time.

Disadvantages. Water, however, possesses certain disadvantages as an extinguishing agent. It is not suitable for use in extinguishing certain combustible liquids, which are lighter than and immiscible with it (see page 22), owing to the fact that the burning liquids tend to float on the water, and may thus be carried about, and spread the fire. Gasoline, petroleum, ether, benzene (benzol), benzine, fats, so-called heavy mineral oils, tar, many waxes, and resins belong to this class. It should be remembered that certain combustible liquids which are heavier than water at ordinary temperatures become lighter than water when heated sufficiently.

In the case of combustible liquids which are lighter than water but miscible with it, the application of a great deal of water under certain circumstances may be effective, but ordinarily it is a rather difficult matter to secure good results with water in extinguishing such combustibles. For example, alcohol is miscible with water in all proportions but when water is thrown on burning alcohol there is danger of extending the fire unless a very large volume of water can be applied in a very short time.

The heat of combustion of most inflammable liquids met with in practice is very high, and, of course, tends to offset the cooling effect of water to a marked extent.

Another disadvantage possessed by water is that it enters into chemical union with certain substances producing heat. For example, water and calcium oxide (quicklime) enter into combination (see page 29), and the reaction is accompanied by the evolution of considerable heat. Water reacts with calcium carbide, with the evolution of heat and the formation of the combustible gas, *acetylene* C_2H_2. (See page 92.)

$$CaC_2+2H_2O=Ca\,(OH)_2+C_2\,H_2$$

Certain metals as potassium and sodium when brought in contact with water decompose it with the evolution of heat and the formation of (combustible) hydrogen. (See Experiment No. 5.) Rubidium, cæsium, calcium, barium, and strontium belong to this class. Manganese, aluminum, and zinc, when in a finely-divided condition, also decompose water; in fact, most metals when red-hot decompose water.

The application of water in streams to finely-divided or pulverant combustibles is attended with the hazard of producing explosive dust-air mixtures. Lampblack, coal dust, metal dust, and many other kinds of combustible dust belong to this class.

An indirect disadvantage possessed by water as an extinguishing agent is its high freezing point (0°C. or 32°F.). As a result, it is necessary to take steps to prevent the freezing of water intended for use as an extinguishing agent. This is often difficult to accomplish under the conditions met with in practice. The addition of calcium chloride, $CaCl_2$, depresses the freezing point of water; and in some cases can be used for this purpose to advantage.

Non-Combustible Mineral Salts. In many cases where the use of water is inadmissible, particularly in the case of burning liquids, dry sand, plaster of paris, barium sulphate, and sodium bicarbonate can often be used effectively. These substances exert a *cooling effect*, and at the same time prevent access of air, if used in sufficient quantities and applied so as to cover the fire.

The addition of mineral salts to water for the purpose of increasing its *cooling effect* is practically of no service in this respect. The thermal capacity of salts often used for this purpose is much too low to increase materially the thermal capacity of water. See page 36.

Gaseous Extinguishing Agents. Under this head come gaseous agents for the extinction of combustion by exclusion or dilution of air. The disadvantage of gaseous extinguishing agents is that they are practically useless when employed in the open, owing to the fact that they are rapidly carried upward and away from the zone of combustion by the air currents that are produced by the heat. In confined spaces they are, however, often effective.

Carbon dioxide is preferable to most gaseous extinguishing agents and is safer to work with. The power of carbon dioxide to extinguish flame in confined spaces is important and receives some practical application. When a substance is allowed to burn in a confined portion of air, the combustion continues till the proportion of oxygen is reduced to a certain point, and a certain proportion of carbon dioxide is present, when the flame is extinguished. The proportion of carbon dioxide required to extinguish flame varies in each case and depends principally on the nature of the combustible and the proportion of oxygen present. For example, the flame of an ordinary candle when allowed to burn in a confined portion of air is extinguished when the oxygen is reduced to about 18 to 19 per cent by volume, and there is at the same time about 2 to 3 per cent by volume of carbon dioxide present; but phosphorus will burn in air which will not support the combustion of the candle flame. In the case of air containing the normal amount

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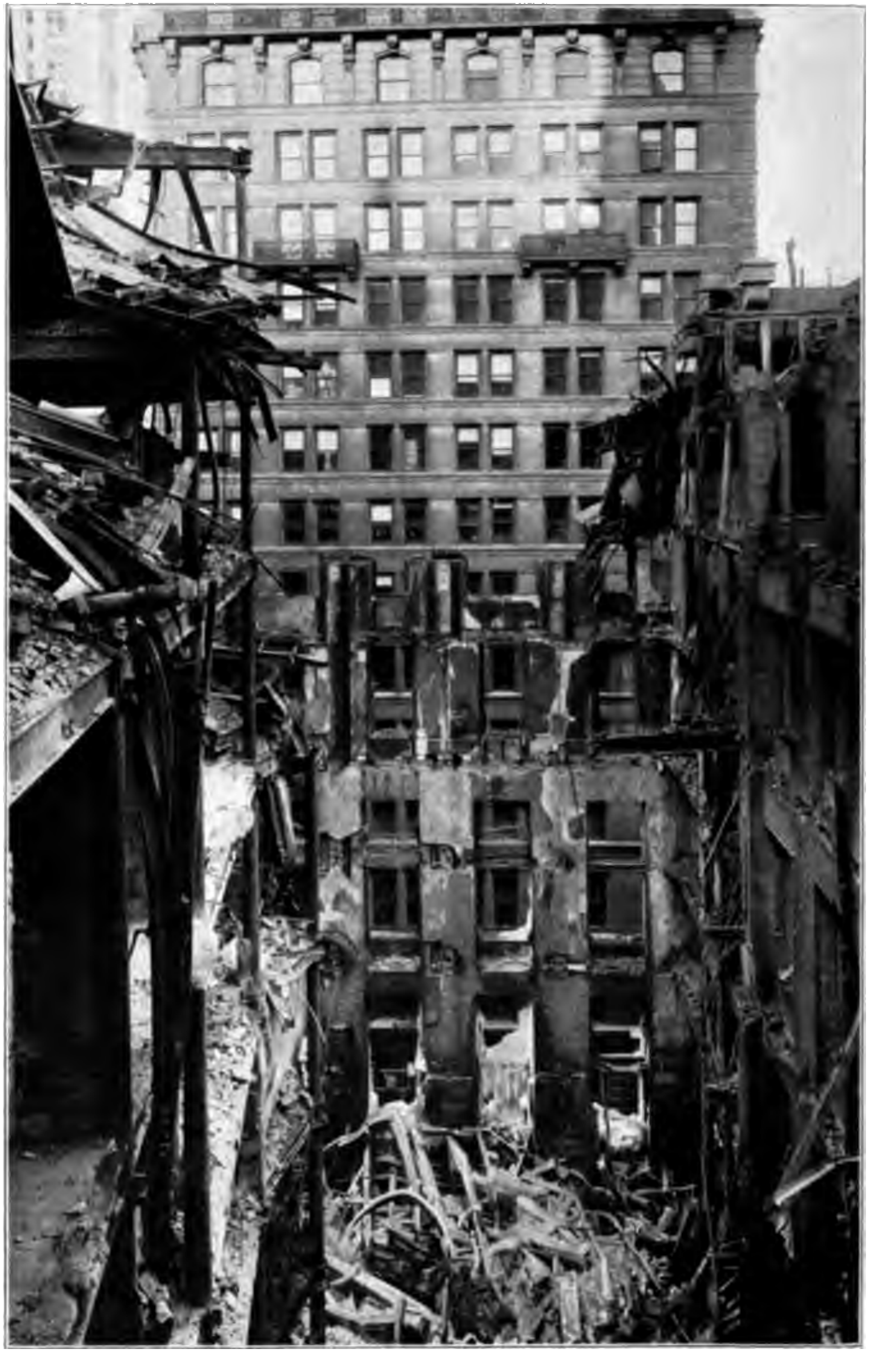
ASTOR, LENOX AND
TILDEN FOUNDATIONS.



INTERIOR VIEW OF RUINS OF EQUITABLE BUILDING

View of Main Collapse Looking North Toward Peter Street, Showing Débris on Top of Safety Deposit Vault

Courtesy of New York Board of Fire Underwriters of oxygen, an addition of about 14 per cent by volume of carbon dioxide is required to extinguish a candle flame; while in the case of coal gas flame, the addition of about 33 per cent by volume of carbon dioxide is required to prevent combustion.

Carbon tetrachloride, CCl_4, is a very volatile liquid which in many cases can be used effectively in extinguishing flame. It mixes with many combustible liquids which are immiscible with water.

EXPLOSIONS

In general, an explosion is essentially a very sudden expansion or transformation of a substance, resulting in a great increase in volume or pressure, usually attended by a loud noise. The term receives a very general application, being applied not only to certain chemical phenomena, but to physical phenomena such as the disruption of a boiler, followed by a sudden expansion of steam in a compressed state, and to such phenomena as the disruption of a fly-wheel running at a high speed. Physical phenomena of this order, however, do not bear any relation to combustion and accordingly will not be treated in this text.

Most explosions are essentially chemical reactions, taking place very rapidly and accompanied by the sudden liberation of heat and a relatively large quantity of gas. Many explosions of this order are produced by rapid combustion, and in some cases both by decomposition and by combustion.

General Nature of Explosions. We have already learned that when any gas is heated it tends to expand, and if heated in a confined space the tendency to expand causes pressure. Furthermore, the higher the temperature to which the gas is heated the greater the tendency toward expansion, and if confined, the greater the pressure produced. It is also true that when a given quantity of heat is very suddenly applied to a given amount of gas, as occurs in an explosion, a comparatively great expansive effect is produced. When such a chemical reaction takes place, the expansive effect, or the force of the explosion, depends principally on:

(1) The nature and quantity of the substance undergoing the chemical change.
(2) The rapidity with which the substance undergoes the chemical change.
(3) The quantity of gas produced.
(4) The heat developed.

Characteristics of Explosives. From the above it is evident that an explosive, from the chemical standpoint, is a substance capable of suddenly undergoing a chemical change with the liberation of a large amount of gas and heat. For example, dynamite, guncotton, nitro-glycerin, and gunpowder when "fired" explode; that is, they are suddenly converted into gases with the liberation of heat, the gases produced tending to occupy a large volume.

Classification. Explosives cannot, it seems, be classified very definitely on a chemical basis, as the behavior and character of different explosives vary to a marked extent. In practice, many of the explosives which are useful for doing work are often referred to as *ammunition* and *blasting materials.*

The maximum effect can be obtained only from a certain class of explosives by means of intermediate explosive agents termed *detonators,* which are themselves very explosive compounds. Explosives which can be made to explode most effectively only by means of detonators include guncotton, dynamite, and nitroglycerin. This class of explosives is often termed *high explosives,* while explosives like gunpowder which are not so powerful are often termed *low explosives.*

Detonators are prepared from a class of explosives, termed *fulminates,* which are violently explosive compounds, the decomposition of which takes place almost instantaneously. As a result, their action is extremely destructive, and consequently they are not suitable for doing many useful kinds of work. They are very sensitive to shock, friction, and heat. The most important one is the fulminate of mercury, which is used in the manufacture of detonators, percussion caps, etc.

The term explosive is also used in a broader sense, being often applied to substances which are capable of producing explosions *when in admixture with other substances.* This class includes oxygen carriers (see page 72), combustible dust (see page 71), dust explosions, and some gases and vapors which, when mixed with the air in certain proportions, form explosive vapor or gas-air mixtures. The oxygen of the air plays an essential part in the explosion of such gases and vapors, and the *mixture* of gas or vapor and air is, therefore, properly termed explosive. It will be evident that either the air or gas taken separately is non-explosive.

TABLE IX

Combustible Gases Lighter than Air

Gas	Approximate Density (Air=1)
Acetylene	.91
Hydrogen	.069
Carbon Monoxide	.967
Coal Gas	.4 to .6

Explosive gas- or vapor-air mixtures are obviously of a different order from substances like guncotton, although in both cases there is a sudden expansive effect produced by heated gases. In the case of guncotton and similar explosives the expansive effect (explosion) is produced, as we have seen, by the sudden transformation of the guncotton into gases with the liberation of heat; at the instant the gas is produced it is in a compressed state, so to speak, and immediately tends to occupy a larger volume; at the same time the liberated heat increases the tendency to expand (pressure). On the other hand, in the case of an explosive mixture of gas and air or of vapor and air, the expansive effect is due principally to the heating of the gaseous products of combustion.

EXPLOSIVE GAS-AIR AND VAPOR-AIR MIXTURES

General Nature. We have learned that when gases are brought together they begin to intermix(diffusion, see page 19), and if left alone finally form a uniform mixture. This is also true of vapors, although some of the vapors which are relatively heavy—such as those of gasoline and carbon disulphide—diffuse with air very slowly. The heavy gas and vapors naturally tend to slowly form mixtures with the air near the floor, while the light gases and vapors rapidly form mixtures first near the ceiling, though in time, of course, the mixture gradually extends over the entire space.

Table IX and Table X show the density* of a number of combustible gases.

When a portion of a combustible gas-air or vapor-air mixture is ignited, the combustion travels to the surrounding parts of the

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*See "Diffusion."

TABLE X
Combustible Gases Heavier Than Air

GAS	APPROXIMATE DENSITY (Air=1)
Alcohol, methyl	1.1
Alcohol, grain	1.6
* Alcohol, denatured	1.4
Carbon Disulphide	2.6
Benzene (Benzole)	2.7
† Benzine	4
Ether	2.6
† Gasoline	3

*Completely denatured—Government Formula I.
†Consists of hydrocarbons of different weights—average density varies.

mixture—in other words propagates itself. Following the path of the combustion is the highly heated gaseous products of combustion, which tend to expand. The velocity at which the combustion advances or propagates itself, is different for different gaseous mixtures and depends on (1) the chemical affinity of the gas or vapor for oxygen; (2) the heat of combustion of the gas or vapor; (3) the proportion of air (atmospheric oxygen) present in the mixture; and (4) the pressure. The higher the velocity of combustion and the heat of combustion the greater the rise in temperature which, of course, affects the expansion of the gases, and with certain gases influences the products of combustion. The expanding gases exert a pressure on the walls of the containing vessel, room, or anything that resists the expansion, and may produce great damage.

EXPLOSIVE RANGE OF GASES AND VAPORS

An explosion of gas-air or vapor-air mixture is, therefore, the result of a *chemical reaction*, taking place between the gas or vapor and the oxygen of the air, except in certain cases when the explosion is produced or aided by decomposition of a gas. (See acetylene.) In studying chemical reactions we learned that when a substance enters into union with oxygen it does so in certain definite proportions (see page 15). Accordingly when a combustible gas or vapor burns in a sufficient supply of air, a certain definite quantity of oxygen, no more or no less, enters into combination with the gas or

TABLE XI

Explosibility of Certain Important Gases and Vapors

Gas	Per Cent
Acetylene	*3 to 82
†Alcohol, ethyl	4 to 13-14
Benzol	2 to 7
Carbon Monoxide	13 to 75
Coal Gas (1)	7 to 30
Ether	3 to 75
Hydrogen	5 to 80
Marsh Gas	5 to 17

*According to Bunte, Clowes, Von Schwartz, Lewis and others. Experiments by the writer with the gas resulting from the slaking of commercial carbide fail to produce explosions in mixtures where proportions of the gas exceed 35 per cent.

†Alcohol vapor begins to condense, at ordinary temperatures, before the percentage of vapor exceeds the upper limit.

Note. — Results obtained by different observers vary, owing mainly to the fact that results are influenced by experimental conditions.

vapor. Hence, if the gas- or vapor-air mixture contains an insufficient quantity of oxygen to satisfy the affinity of the gas or vapor for oxygen there will be a quantity of the unburned gas or vapor left over. On the other hand, if there is present any excess of atmospheric oxygen over the amount required for the reaction, this excess will be left over. In short, if there is any excess of gas or oxygen in the mixture this will not only fail to take part in the production of heat and flame, but will absorb heat, thereby preventing the mixture from attaining as high a temperature and burning as rapidly as it would in the absence of an excess of gas or air; in other words, an excess of air, gas, or vapor retards combustion by taking up heat and diluting the mixtures.

It is further found that if too great an excess of either gas or air is present in the mixture it is not capable of burning. In other words, in the case of each combustible gas or vapor not only must a certain minimum proportion of gas be present in order for the mixture to burn, but there is also a maximum limit to the proportion of gas beyond which the mixture will not burn. The proportions depend on the nature of the gas or vapor and differ in every case. The range between the minimum and maximum proportions by volume of a gas or a vapor required to form inflammable mixtures with air is termed the *explosive range* of that gas or vapor; the minimum proportion being termed the *lower limit,* and the maximum proportion the *upper limit.*

For example, the lower limit of explosibility for coal gas is about 7 per cent and the upper limit 30 per cent making the range of explosibility equal to the difference between these two limits, or 23.

In the case of gasoline vapor (under ordinary conditions) 1½ to 2 per cent by volume is the low limit of explosibility; hence, mixtures of gasoline vapor and air containing less than 1½ to 2 per cent of vapor do not take fire and burn when a flame or spark is applied. About 6 per cent is the upper limit and accordingly the explosive range for gasoline vapor is 4 to 5.

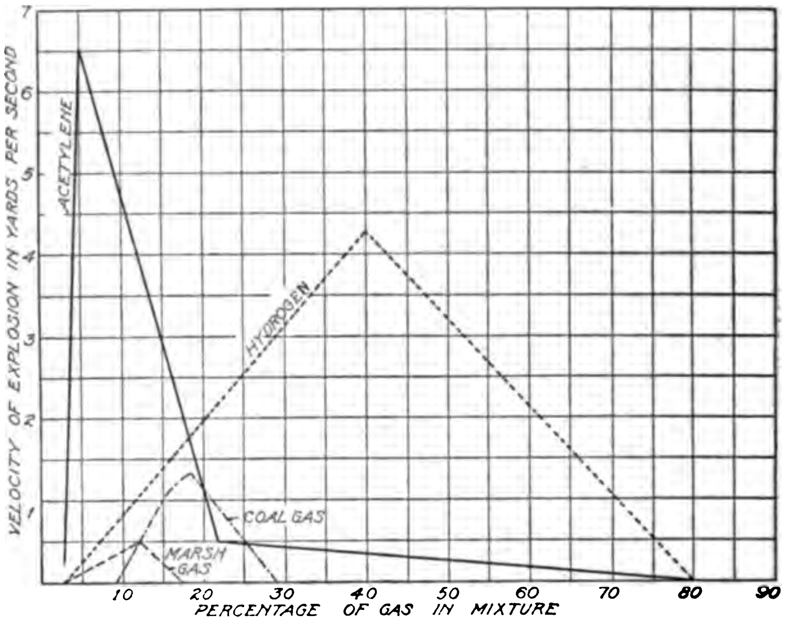

Fig. 24. Rate of Propagation of Combustion in Gas-Air Mixtures By Herbert and Harry Ingle (see note p. 69).

The range of explosibility varies with the temperature, the pressure, the amount of moisture in the atmosphere, the size and shape of the enclosure, and the method of ignition.

Table XI shows the approximate relative range of explosibility for certain important gases and vapors.

Fig. 24 gives a graphical representation of the rate of propagation of the combustion of certain gas-air mixtures. It will be seen that in the case of each gas the rate of combustion varies with the proportion of gas in the mixture. Mixed with air in certain proportions these gases burn rapidly with the production of a high temperature, and as a result a sudden expansion of the gaseous products of combustion occurs, which may cause great pressure. The violence of explosions of gas-air or vapor-air mixtures depends principally on the rate of propagation of the combustion and the heat of combustion.

DUST EXPLOSIONS

Nature. Many solid substances when in a finely-divided condition, suspended in the air in certain proportions, are capable of burning very rapidly with the sudden production of gas and heat, and thereby causing an explosion. Such a mixture is termed an *explosive dust-air mixture,* and the explosion produced by the combustion of the mixture is known as a *dust explosion.*

When an explosive dust-air mixture is ignited at any point, say by a spark or flame, the combustion travels from the ignited portion to surrounding portions—that is, propagates itself—and, at the same time, heat and gaseous products of combustion are produced. The latter occupy a considerably larger volume than was previously occupied by the dust, and thus produces an expansive effect; the heat evolved by this combustion, of course, greatly increases the expansive effect. If the rate of propagation of the combustion of the mixture is very rapid, a great deal of hot gas will very suddenly be produced. Dust explosions usually take place very suddenly and are generally of a violent nature.

The force of a dust explosion will depend principally upon: (1) The combustibility (affinity for oxygen) of the dust, (2) The fineness of division (which favors intimate contact with the oxygen of the air) of the dust, (3) The rate of propagation of the combustion; that is, the rapidity with which the chemical reaction takes place, (4) The heat of combustion, (5) The quantity of the dust-air mixture, and (6) The proportions of dust and air in the mixture.

Certain Working Conditions. Most combustible substances when in the form of dust are capable of forming explosive dust-air mixtures, and it should be noted in this connection that many substances which, when in the compact form, will burn only very slowly, are capable of burning very rapidly when disseminated in the air in the form of dust. Certain dust may in some cases absorb or occlude some of the oxygen of the air and thus become more combustible owing to the intimate contact of the molecules of dust with the absorbed oxygen.

The actual amount or weight of dust in the mixture is of secondary importance to the fineness of division of the dust for it will be evident that the finer the dust the greater the number of particles or molecules that will be oxidized in a given time, and as a result the greater amount of heat and gas produced. In order for the mixture to be explosive there must be a sufficient proportion of dust present to propagate the combustion, and yet the proportion of dust should not be so great as to require for its combustion more oxygen than is present in the mixture. This latter condition seldom occurs, because, when a large amount of dust is thrown into the air, a portion settles out almost immediately.

Sparks, flame, or some source of heat is necessary to cause the ignition of dust-air mixture as it is not subject to explosion by concussion or shock.

The presence of combustible dust in explosive vapor-air or gas-air mixtures often greatly aids in the propagation and violence of the explosion.

Typical Explosive Dusts. Some of the most explosive dust-air mixtures known are formed by flour and air, and the explosions from this mixture are very violent. Coal dust is also capable of forming highly explosive mixtures with air. The explosions in the case of coal dust result in the formation of carbon monoxide, a very poisonous gas, which often renders the work of rescue dangerous for some time after the explosion has occurred.

Malt dust and sugar dust have caused dangerous explosions; in fact, most combustible dust is to be regarded as dangerous when suspended in the air.

OXYGEN CARRIERS

There is an important class of oxygen compounds, known chemically as oxidizing agents, which may be regarded as supporters of combustion or *carriers of oxygen.* They are not themselves combustible or explosive, but behave under certain conditions like the element oxygen itself, being capable of supporting the active combustion of many substances. They consist of oxygen, chemically combined with one or more other elements *in such a way* that a portion of the oxygen may be regarded as loosely combined. This loosely-combined oxygen is ready, so to speak, to depart from its associates in the compound and recombine with certain other substances. In other words, in this class of compounds the chemical affinity of a portion of the combined oxygen for the elements with which it is united is not very strong, and as a result heat, and in some cases friction or shock, causes the liberation of oxygen. At the moment this oxygen is set free it is in the nascent state (see page 10), and is, therefore, very active chemically. If the oxygen carrier is in contact with a combustible substance when the oxygen is being liberated a rapid reaction between the oxygen and the combustible may occur, so rapid in some cases as to produce a violent explosion.

The reaction is, of course, influenced by the prevailing temperature, but as oxidation takes place much more readily and rapidly in undiluted oxygen (particularly when in the nascent state) than in the air, the process of oxidation itself may begin at comparatively low temperatures, and thereby generate sufficient heat to cause combustion or explosion. Among the most important oxygen carriers are certain *nitrates* (*nitric acid*), *peroxides*, and *chlorates*.

Nitrates. Some of the important nitrates are: nitrate of soda, $NaNO_3$, or Chili saltpeter; nitrate of potassium, KNO_3, saltpeter; ammonium nitrate, NH_4NO_3; barium nitrate, $Ba(NO_3)_2$; and strontium nitrate, $Sr(NO_3)_2$. The above compounds are regarded as salts of nitric acid (see page 15), HNO_3, being formed by the replacement of the H in the acid. Nitric acid is itself a carrier of oxygen.

Nitric Acid.

SYNONYMS—ACIDIUM NITRICUM, AQUA FORTIS

Nitric acid is a fuming corrosive liquid, the vapors from which are very irritating. The commercial acid has a reddish-yellow color, and consists principally of oxygen, a portion of which it readily parts with. When brought in contact with warm organic materials such as sawdust, charcoal, paper, and the like, oxidation takes place so rapidly that the process may soon become one of combustion. In some cases nitric acid may cause a fire without the application of any external heat by oxidation of dry combustible matter.

EXPERIMENT 11.—Apparatus required: Porcelain dish such as was used in Experiment 10. Burner or other source of heat.

Chemicals required: Small quantity of powdered charcoal; about 30 c.c. of *strong* nitric acid.

Dry the charcoal by heating it slightly for some time; keep it constantly under observation. When apparently dry, and while still warm, allow *a few drops* of nitric acid to fall on a *few* grams of charcoal in the dish. The brown fumes given off consist of oxides of nitrogen; a portion of the acid combines with the carbon, producing heat, and finally the charcoal takes fire. *Caution—Danger*—Do not add the acid rapidly.

Nitrate of Soda. When exposed to the air nitrate of soda absorbs moisture, and if it is in contact with organic matter, such as fibers, the absorbed moisture carries some of the nitrate into the organic matter and thereby stores in it available oxygen. Bags used for sodium nitrate usually become so impregnated with the salt, that they can easily be ignited by a small spark or other source of heat. When heated in contact with organic matter the salt gives up a portion of its oxygen, possibly causing combustion or explosion.

Potassium Nitrate. Potassium nitrate is similar to sodium nitrate in many respects; it does not, however, absorb moisture from the air, and is, therefore, preferable to sodium nitrate for use in the manufacture of gunpowder, etc. (See page 87.) When heated it decomposes as follows:

$$KNO_3 = KNO_2 + O$$

Ammonium, barium, and strontium nitrates act very much like potassium and sodium nitrates. Ammonium nitrate is used in the manufacture of many explosives, while barium and strontium nitrates are used in fire works.

Peroxides. Some of the important peroxides are: barium peroxide, BaO_2; lead peroxide, PbO_2; manganese peroxide, MnO_2; potassium and sodium peroxides, K_2O_2, Na_2O_2; and hydrogen peroxide, H_2O_2. The peroxides give up oxygen at much lower temperatures than the nitrates and are more hazardous.

Barium peroxide. Barium peroxide like other carriers of oxygen is capable of reacting violently with combustibles, especially organic matter such as paper, wood, etc.

EXPERIMENT 12.—Apparatus required: Porcelain dish such as was used in Experiment 10; source of heat.

Chemicals required: About 10 grams of powdered barium peroxide; small quantity of sawdust.

Mix two or three grams of the peroxide with an equal amount of sawdust. Place in the dish, and support same over burner as shown in Fig. 21. Heat gradually. Do not hold the face or hands over the dish during the heating. When heated sufficiently the mixture will burn violently. *Caution*—Heat far away from combustibles.

The peroxide of potassium, sodium, and lead behave like barium peroxide in this respect.

Hydrogen Peroxide.

SYNONYMS.—HYDROGEN DIOXIDE,
OXYGENATED WATER, H_2O_2

Hydrogen peroxide is a syrupy liquid with a bitter taste. It is a powerful disinfectant. In the undiluted state it is very explosive, especially in the presence of dust. It is soluble in water and is generally used in the form of a weak aqueous solution. Its use in this form is not ordinarily attended with danger.

Chlorates. The most hazardous compounds of this class are the *chlorates.* They may readily be induced to liberate oxygen by heat, concussion, or friction. The more important chlorates are those of potassium and sodium.

Potassium and Sodium Chlorates. The ease with which these salts decompose into the chlorides and oxygen with the evolution of a great deal of heat renders them very dangerous. If heated or subjected to blows or sufficient friction when in contact with organic matter they are liable to produce explosions of great violence. They also form explosive mixtures when associated with sulphur or certain sulphides (see page 89). If a little powdered potassium chlorate and sulphur, for example, are rubbed together in a porcelain mortar, they detonate violently.

Potassium or sodium chlorate even when stored out of contact with organic matter, may cause explosions in burning buildings if the hot chlorate and the smoke (containing organic matter) come in contact under suitable conditions. A very slight heat may induce explosions of mixtures of a chlorate and organic matter. The dangerous character of the chlorates becomes more evident when we consider that they are capable of inducing combustion even ***under water***, no air being required, Fig. 25.

Ozone. Ozone, O_3, is oxygen in such a state that the molecule consists of three atoms rather than two, as in ordinary oxygen. Ordinary oxygen is changed into ozone by electric discharges taking place in oxygen or in the air. When heated to a temperature of about 250°C. the ozone is broken down into ordinary oxygen.

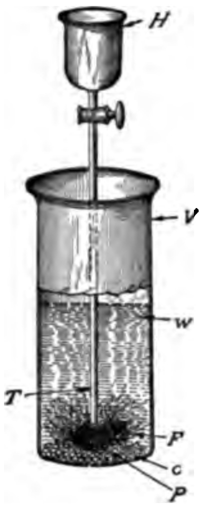

Fig. 25. Explosion Under Water

The property which certain elements have of being converted into different forms is called *allotropy*. Thus, we may say ozone is an allotropic modification of oxygen; another example is afforded by carbon, the brilliant diamond being an allotropic modification of the black carbon. Allotropy in many cases, as is true with ozone, is probably due to a difference in the number of atoms of the element contained in a molecule.

Ozone is a gas, having a strong unpleasant odor. It is a strong oxidizing agent, is very unstable and readily combines with metals and organic matter, the reaction taking place with violence under suitable conditions. Hence, ozone is classed with the carriers of oxygen.

RELATIVE COMBUSTIBILITY OF SUBSTANCES. FIRE HAZARD

The chief value of a knowledge of chemistry of combustion is the means it affords of obtaining measurements which indicate the relative combustibility of certain substances under varying conditions. This information is obviously of the utmost importance to the fire insurance raters and underwriters in the accurate determination of the fire hazard of the many combustible substances met with in practice. In fact, the lack of such information might often lead to tremendous losses of life and property.

When we know certain properties of a liquid we can indicate its chemical conduct and its behavior relative to fire. For this purpose the more important substances may be divided into three general classes: I. *Combustibles;* II. *Substances which may cause fires or explosions without access to air;* and III. *Non-combustibles.*

I. **Combustibles.** Combustibles are substances that will burn in the air. This class may be divided into: (1) *Solid,* (2) *Liquid,* and (3) *Gaseous.*

(1) *Solid* combustibles may be divided into two classes (a) *non-volatile* and (b) *volatile.*

(a) The two most important members of the non-volatile class are charcoal and coke (see page 81).

(b) Most solid combustibles belong to the volatile class. The combustibility of members of this class is indicated principally by: flashing point; heat of combustion; behavior of the substance when burning; volatility, and chemical stability.

(2) *Liquid* combustibles may be divided into three general classes:

(a) Those which give off inflammable vapors in material quantity at temperatures (indicated by flashing point) below the average room temperature (taken as about 20°C. for this purpose). Gasoline carbon disulphide, ether, petroleum ether, acetone, alcohol, etc., belong to this class. This is the most hazardous class of liquids.

(b) Those which give off in material quantity inflammable vapors at temperatures below, say 65°C. but somewhat above ordinary temperatures. The members of this class are not so liable at ordinary temperatures, to be ignited by a small flame, and are less hazardous than the foregoing class. If slightly heated, however, they give off inflammable vapors readily. Kerosene and turpentine are important members of this class.

(c) Those which do not give off inflammable vapors in material quantity except at high temperatures. To this class belong the so-called heavy mineral oils, and also most of the oxidizing vegetable oils. As the oxidizing oils are subject to spontaneous ignition they are more hazardous than the flashing point would indicate.

In determining the combustibility or fire hazard of members of any of these three classes of liquids it is necessary to take into consideration other properties than the flashing and burning points. In certain cases the flashing point indicates to a large extent the hazard of a liquid. As a rule, for example, the most explosive vapor-air mixtures are from liquids having very low flashing points. In the case of liquids which have flashing points near ordinary temperatures we cannot decide their relative hazards on the flashing point basis alone. The volatility of the liquid is not defined completely by the flashing point, but is only indicated. Nor does the flashing point tell us very much about the character of certain mixtures of liquids.

The *principal characteristics indicative of the hazard of liquids of classes* (*a*) *and* (*b*) may be considered, irrespective of their relative importance, to be as follows:

(1) Flashing point; (2) Burning point; (3) Ignition point; (4) Heat of combustion; (5) Volatility; (6) Explosive range of vapors; (7) Rate of propagation of combustion of vapor-air mixtures; (8) Violence of vapor-air explosions; (9) Ability as a factor in spontaneous ignition; (10) Density of vapor; and (11) Chemical stability.

The most important *characteristics indicative of the hazard of liquids of class* (*c*) are:

(1) Flashing point; (2) Burning point; (3) Ignition point; (4) Heat of combustion; (9) Ability as a factor in spontaneous ignition; and (11) Chemical stability.

Characteristics 5, 6, 7, 8, and 10 are evidently of secondary importance in determining the hazard of members of class (c), owing to the fact that they do not give off vapors in material quantity except at high temperatures, hence they are not liable to produce explosions under ordinary conditions.

In consideration of the explosive range of vapors, we know that in certain proportions the explosives will be very violent, while in the proportions bordering on the limits of the range, the explosions will be less violent. A vapor with a wide range is more liable under practical conditions to become mixed with air within the wide limits than a vapor with a narrow range. The ignition point is evidently an essential factor in determining hazard. The vapor density is also of importance. If the vapors are much heavier than air they will diffuse very slowly and may accumulate in vessels or a closed space and remain for some time, or they may flow to a distant fire and ignite. The volatility is of importance. How rapidly the liquid will give off vapors at ordinary temperatures and also when heated are very important questions. The volatility is often measured by the vapor pressure (see page 20) and the boiling point.

As a general rule in the case of given liquids, other characteristics being equal or equivalent in respect to combustibility, the lower the flashing point the higher the relative hazard. The hazard, however, is not in direct proportion to the flashing point, as is illustrated by the curve shown in Fig. 26. The "height" of the curve measured on the line *AB* indicates the relative hazard. Following the line *BC*, it will be seen that as the flashing point rises, the curve falls, but not in direct proportion. If the relation between hazard and flashing point were in direct proportion, this would be indicated as in Fig. 27. The hazard rises more rapidly, as shown by the curve, as the flashing point approaches average room temperature. At about 200°C. the curve nearly coincides with a straight line while at about 40°C. it nearly coincides with the arc of a circle.

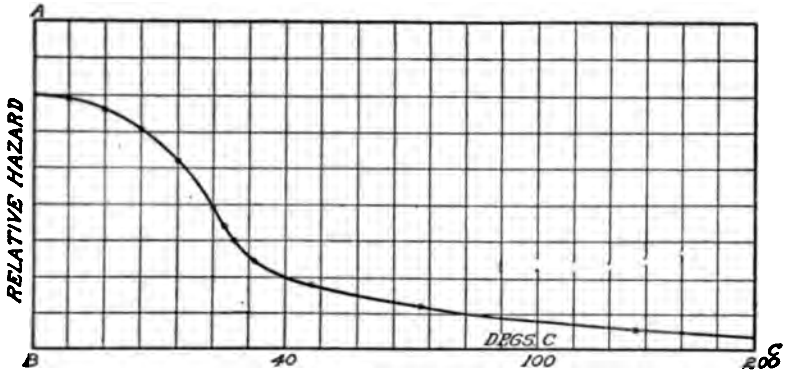

Fig. 26. True Relation of Flashing Point to Relative Hazard

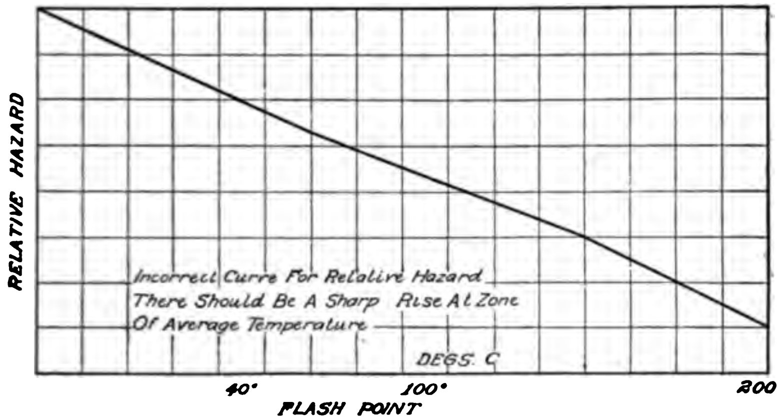

Fig. 27. Incorrect Curve for Relative Hazard

(3) *Gases.* In considering gases the following properties are of importance as indicating the relative hazard: Explosive range; Violence of explosions; Rate of propagation of combustion; Heat of combustion; Ignition point; Density (diffusibility); and Chemical stability.

II. **Substances Which Produce Explosions or Fires without Access of Air.** This includes commercial explosives, such as gunpowder, guncotton, dynamite, etc., also oxygen carriers and other substances. Owing to the diversified nature of members of this class, the properties indicative of the hazard differ considerably, making a very definite classification impractical.

III. **Non-Combustible Substances.** This class, obviously, includes substances which do not take part in or cause fires, and, therefore, have no flashing point, burning point, or ignition point within the range of temperature met with in practice.

CERTAIN COMBUSTIBLES

A large number of important combustibles have already been discussed, and their characteristic properties having a bearing on their relative combustibility pointed out; these will not, therefore, require mention in the following pages except in cases where new matter in reference to any of them is introduced.

SOLIDS

Coal. This well-known mineral is of vegetable origin, and is found in various parts of the world in the crust of the earth. It consists principally of carbon. Among other constituents found in coal are, hydrogen, oxygen, nitrogen, sulphur (usually present as pyrites iron sulphide), and ash (non-combustible mineral matter).

Coal contains volatile matter (gas, tar, and many complex compounds) and may be divided, according to the content of volatile matter, into *soft* or *bituminous coal* and hard or anthracite.

Bituminous. Bituminous coal contains from about 15 to 40 per cent volatile matter. It burns with a smoky flame on combustion, evolving large quantities of gases and vapors. It is employed for the manufacture of coal gas and coke and for most ordinary heating purposes.

The spontaneous ignition of bituminous coal is quite generally attributed to the oxidation of iron pyrites, but this explanation is not satisfactory. Cases of spontaneous ignition of coal free from pyrites are on record. Recent investigations seem to show that the spontaneous heating of coal is due to the oxidation of a part (the organic matter) of the coal rather than to iron pyrites. In the present state of the art the most practical means of preventing coal from heating spontaneously is by securing proper ventilation, so that the heat will be carried away by the air as fast as it is generated by the slow oxidation of the coal.

As already mentioned coal dust is capable of forming explosive mixtures with air.

Anthracite. Anthracite coal is hard, yielding from 5 to about 10 per cent of volatile matter. It is more difficult to ignite than bituminous coal, and burns with the evolution of a relatively large amount of heat and the formation of very little flame and smoke. This form of coal is considered to be less hazardous than bituminous or soft coal.

Coke. When the volatile constituents of coal are driven off by heat (distillation) without access of air, the product is called coke. It is also obtained in the manufacture of coal gas. It retains the inorganic matter (ash) of the coal, and also small amounts of hydrogen, oxygen, nitrogen, and sulphur. It is difficult to ignite and is not subject to spontaneous heating.

Phosphorus

SYMBOL P ATOMIC WEIGHT, 31
MOLECULAR WEIGHT, 124

Phosphorus is a volatile, translucent, almost colorless or slightly yellow, waxlike solid. It appears faintly luminous in the dark. Owing to its strong affinity for oxygen, and the relatively low temperature at which the affinity operates (ignition point), phosphorus oxidizes very rapidly when exposed to the air, and is subject to spontaneous ignition. It is for this reason best preserved under water.

It is used in the manufacture of matches; and also on account of its extremely poisonous property as a constituent of rat poison*.

Red or amorphous phosphorus is an allotropic modification

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*Many rat poisons on the market, on account of the presence of phosphorus, are subject to spontaneous ignition.

(see page 76), produced by heating ordinary phosphorus out of contact with the air. Red phosphorus is *slowly* oxidized when exposed to moist air. It is not poisonous, and has no taste or smell. Its chief use is in the manufacture of a class of matches, termed "safety matches".

Matches. The matches met with in practice today may be divided into two general classes: the ordinary or *parlor match* and the *"safety" match.*

The *ordinary matches* can easily be ignited by friction or slight heat. The compositions of the heads of different brands vary considerably, but always contain *phosphorus*, and are evidently very dangerous. Fires caused by such matches being subjected to accidental friction or heating are of constant occurrence, and the loss of life and property due to their use is enormous[*]. Unfortunately they are far more commonly used than the "safety" match.

"Safety" matches. "Safety" matches are made with splints of wood tipped with an oxidizing agent-carrier of oxygen—together with some combustible substance and inert materials; they are ignited by being rubbed upon a prepared surface, consisting essentially of red phosphorus[†]. The compositions employed in the different brands vary considerably, and as a result some kinds are far more safe for use and storage than others. In most cases "safety" matches will not ignite by ordinary friction on any but the prepared surface[‡], and, therefore, they are not so liable to be accidently ignited as the *ordinary* match. Their more general use is strongly recommended because of their less hazardous and less poisonous character.

Wood. The composition of this well-known substance varies considerably according to the age and nature of the wood. The essential constituents include: the *fiber*, consisting principally of cellulose, $C_6H_{10}O_5$; the *sap; water;* and often *resinous matter.*

When dry, wood is very easily ignited, and burns readily with the formation of flame and smoke. Sawdust when piled up in heaps while in the damp state undergoes decay, accompanied by the evolution of heat, which may result under favorable conditions in charring and spontaneous ignition.

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[*] The fire loss in this country is about $250,000,000 per annum. What proportion of this loss is due to the use of ordinary matches cannot be determined exactly, but it is considerable.

[†] It is to be noted that the red phosphorus is not liable to produce spontaneous heating.

[‡] Some "safety" match compositions may easily be ignited by being drawn rapidly along a smooth surface.

Charcoal, Carbon Black, Lampblack, Vegetable Black. These forms of carbon have been referred to (see page 31). They are essentially finely-divided charcoal; hence, they are porous and capable of absorbing gases with the evolution of heat.

They often contain oil which renders them more liable to spontaneous ignition. When free from oil and material quantities of foreign matter they are not dangerous, if handled and stored so as to avoid exposure to moisture and to marked changes in temperature. It is important to note that the combustion of such materials often proceeds quietly under the external surface without the formation of flame or smoke and may escape detection for some time.*

Magnesium. Magnesium, Mg, is a silvery white metal. It is combustible in the air, easily being ignited when in the form of powder or wire, burning with a brilliant white light, forming magnesium oxide, MgO. It is used in the manufacture of flash light preparations.

COAL TAR AND BY-PRODUCTS

Coal tar is of a complex composition, containing about one hundred and fifty different substances. It is obtained by the distillation of coal in the manufacture of coal gas, and also as a by-product in the manufacture of coke. It is a viscous liquid of a black color, having a very characteristic odor. The flashing point varies according to the content of readily inflammable and volatile gases and vapors. Many crude tars give off inflammable vapors at or below ordinary temperatures.

When subjected to distillation, a separation of some of its constituents takes place, the ones with low boiling points passing over first and the others following in the order of their boiling points. In addition some of the vapors are decomposed by the heat required in the process, producing very different substances. Many of the constituents pass off as gases at the beginning of the process. The portions coming over at different temperatures are termed *distillates*. The principal distillates are: First runnings; light or medium oils; heavy oil (green oil); anthracite oil; and residue of pitch.

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*A box of about two cubic feet capacity was filled with carbon black which was then ignited. Five university students inspected the burning material, but failed to observe the combustion which was very active about an inch below the surface of the black.

The percentage composition of the distillates depends upon the nature of the tar and the temperatures at which the distillation is conducted. The various fractions are purified with sulphuric acid and caustic soda and redistilled, yielding principally: Benzene, C_6H_6; toluene C_7H_8; naphtha; carbolic acid; naphthalene; creosote oil; lubricating oil; anthracene; lamp black; pitch; and coke.

Benzene. Benzene, also called benzol, is a volatile, colorless liquid, having a tarry odor. It boils at 80-81°C. and freezes at about 0°C. It gives off inflammable vapors at ordinary temperatures,* and is a very hazardous liquid.

Coal-Tar Naphtha. Naphtha is a mobile, highly inflammable liquid, having a tarry odor. It is a mixture of hydrocarbons, the specific gravities ranging from about .875 to about .887.

Toluene. Toluene, C_7H_8, is a mobile, colorless liquid. It is very inflammable, but not as dangerous as benzene.

Benzene and toluene are used principally as solvents for oils, fats, resins, etc. Naphtha is used as a solvent for rubber, and also for lighting purposes.

Naphthaline. Naphthaline, $C_{10}H_8$, is a white, volatile substance, having an agreeable odor when pure, but a very objectionable odor when in the crude state. It is used for increasing the illuminating properties of coal gas, and also as an insecticide (moth balls). The presence of the vapors in fabrics renders them very inflammable.

Creosote Oil. Cresote oil, also called *heavy oil* and *dead oil*, is a heavy, dark-brown oil with an odor of coal tar. It is heavier than water, the specific gravity ranging from 1.058 to 1.124. The composition of creosote oils is very complex from a chemical standpoint, and varies materially according to the process of manufacture. In some works that portion of coal tar distilling between 200° and 300°C. is used. Residual oils from the manufacture of various products such as carbolic acid and naphthalene are also used. Creosote oils contain among other substances, tar acids, various neutral oils, anthracene and naphthalene. The main application of creosote oil is for preserving timber. The impregnation of timber with the oil hinders the subsequent absorption of water, and has a strong antiseptic action. Once ignited creosote oils burn very rapidly with the formation of flame and smoke.

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*See table of flashing points, page 56; also explosive ranges of vapor, page 69.

PETROLEUM AND BY-PRODUCTS

Crude petroleum, also called *rock oil* and *mineral oil*, is a natural oil, found at various depths in many parts of the world. Its composition and character vary considerably. It consists essentially of a very large number of solid, liquid, and gaseous compounds of hydrogen and carbon (hydrocarbons). Most of these hydrocarbons are comparatively stable and are called paraffin hydrocarbons.

The inflammability of crude petroleum from different wells varies considerably. Many varieties give off inflammable vapors at very low temperatures, and are, therefore, extremely hazardous.

When subjected to distillation a separation of the petroleum constituents takes place. Some of the principal products obtained by distillation and refining are: Cymogene; petroleum ether; gasoline; benzine; naphtha; kerosene or burning oil; mineral lubricating oil; vaseline; and paraffin wax.

Cymogene. Cymogene is gaseous at ordinary temperatures, and is very inflammable.

Petroleum Ether and Gasoline. Petroleum ether and gasoline are very volatile liquids, having characteristic odors. They consist of mixtures of light, highly inflammable hydrocarbons, and belong to the most hazardous class of liquids. They are used principally as solvents for resins, fats, etc., and for carbureting gas.

Benzine and Naphtha. Benzine and naphtha are less volatile than gasoline, and are not so highly combustible, but give off inflammable vapors below ordinary temperatures, and are very hazardous. They are used as solvents, and as substitutes for turpentine.

Kerosene. Kerosene consists of a mixture of hydrocarbons, and is usually of a slightly yellow color. It has a characteristic odor. The inflammability of kerosene varies considerably owing to the fact that the mixtures sold under that name are not uniform. Some contain a high percentage of volatile and more inflammable hydrocarbons, and are, therefore, dangerous. As enormous quantities of kerosene are used for lighting purposes, it is very important that the product be freed from the lighter and more inflammable hydrocarbons before use. The constant occurrence of a great number of accidents from kerosene, resulting in loss of life and property, makes evident the danger of permitting the sale of kerosene which is capable of giving off inflammable vapors at or near ordinary temperatures. The flashing point of kerosene is specified by law in certain states.

It is considered that kerosene for lighting purposes should have a minimum flashing point of about 60°C. in order that accidental contact with a small flame under ordinary circumstances may not be liable to result in a fire or explosion.

Mineral Lubricating Oils. Mineral lubricating oils vary greatly in character, some of them being very thin and others semi-solid at ordinary temperatures. As a rule they are not very hazardous, having relatively high flashing points. When heated sufficiently, however, they burn very rapidly.

Vaseline and Paraffin Wax. Vaseline and paraffin wax are very similar to mineral lubricating oils in respect to fire hazard.

MISCELLANEOUS PRODUCTS

Vegetable and Animal Oils. Linseed and cotton seed oil, olive oil, lard oil, tallow oil, and marine animal oil, have as a rule comparatively high flashing points. The important factor relative to members of this group is their liability to produce spontaneous heating.

Highly Inflammable Liquids. This class of liquids includes *gasoline*, *petroleum ether*, and *benzene*, and is capable of readily producing explosive vapor-air mixtures.

Acetone. Acetone or dimethyl ketone, C_3H_6O, is a colorless liquid of characteristic odor. Boiling point 132°F.

Disulphide of Carbon. Carbon disulphide, CS_2, is a colorless, heavy, mobile liquid with a specific gravity of 1.272 (at 15.5°C.). When pure it is practically odorless, but as met with in practice, it has a very repulsive odor. It boils at 46°C., has a very low ignition point, 150°C., and is probably the most hazardous member of this class of liquids. It burns with the production of carbon dioxide and sulphur dioxide, the latter a very irritating gas. The relative density of its vapors contributes to a marked extent to its hazard, owing to the fact that they may flow to distant fires or hot bodies and ignite. Carbon disulphide should not be exposed to the air within 50 feet of flames or hot bodies. In any case where it is used, the greatest possible caution should be exercised.

Ether. Ether, also called ethylic ether, sulphuric ether, æther, methylated ether, $(C_2H_5)_2O$, is a colorless and very volatile liquid.

Varnishes and Lacquers. These are liquid mixtures of various compositions, and often consist of resins dissolved in alcohol, benzene, acetone, or petroleum ether. Solutions of resins in linseed oil or turpentine are also met with in practice. When highly inflammable solvents are used, the products are very hazardous. In general, solutions of resins in turpentine are somewhat more hazardous than kerosene. Linseed oil varnishes are as a rule capable of causing spontaneous heating when mixed with fabrics, cotton waste, etc.

Spontaneous Ignition of Liquids by Electricity. In the use of highly inflammable liquids, particularly benzene, it is important to note that ignition may be caused by electrical discharges produced by friction of the liquids and fabrics. Recent investigations show that benzene and wool when brought together so as to produce friction (rubbing) are especially liable to take fire, owing to the generation of electricity which under certain conditions may pass to a metallic object or the hand with the production of a spark. This phenomenon is more liable to occur when the temperature is low and the air dry.

CERTAIN EXPLOSIVES

Gunpowder. The explosive known as gunpowder is a mechanical mixture of charcoal, sulphur, and saltpeter, the proportion varying according to the purpose for which the powder is intended. Rifle powder usually is made up in the following proportions: *Saltpeter*, KNO_3, 75 per cent; *sulphur* 10 per cent; *charcoal* 15 per cent.

The composition of many blasting powders is about the same. Sodium nitrate is sometimes used instead of potassium nitrate because it is cheaper than potassium nitrate and contains more oxygen; however, it has the disadvantage of being hygroscopic, *i.e.*, it absorbs moisture from the air*. Ammonium nitrate is also used in certain powders but it is also hygroscopic. Potassium chlorate is sometimes used in certain powders, the chlorate giving up its oxygen more easily and quickly than the nitrates of potassium or sodium. Such powders are sometimes used for blasting purposes, but are not suitable for fire arms. They are very sensitive to shock and extremely hazardous.

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*On account of the presence of certain hygroscopic impurities.

It will be seen that gunpowder carries its own supporter of combustion in the form of a nitrate; the presence of air is not, therefore, necessary for the combustion of the powder. The oxygen of the nitrate goes over to the carbon, forming carbon dioxide and also carbon monoxide, which are, as we have learned, gases, and, of course, tend to occupy a much larger volume than was occupied by the powder. The reaction is accompanied by the production of heat which obviously increases the expansive effect. Other products of combustion occur, depending on the nature of the powder and the conditions.

Small quantities of powder will burn in the open without exploding, that is to say, when a small quantity burns in the open the combustion is not so rapid and the expansion is not, therefore, so sudden as when a large quantity burns. When larger quantities burn the pressure becomes greater at the beginning of the combustion and causes more rapid combustion.

The ignition point of most gunpowders ranges from about 265°C. to 320°C.; the nature of the powder and the form it is in influence the ignition point. Sparks from steel and other sources vary in intensity and may or may not ignite the powder according to the size and temperature of the spark and the conditions. Under certain conditions gunpowder may be ignited by friction or a sudden blow. The explosion by blow is more liable to be caused by the impact of bodies of the same composition. For example, such an explosion may more easily be produced by striking iron against iron or copper against copper than by striking iron against copper. It is advisable, therefore, in many cases, to provide powder magazines with doors which turn on hinges of different composition, say bronze and copper.

Although the hazard of gunpowder resides more in its explosive combustibility than in its tendency to explode by shock or detonation, yet in a confined space it may give rise to *very* violent explosions.

Fire Works. Colored fire compositions usually consist essentially of an oxygen carrier, such as potassium chlorate or sodium nitrate, together with easily combustible substances, often sulphur, and certain compounds to give color to the fires. Antimony sulphide is often substituted for or used with the sulphur, and occasionally finely-divided wood is added.

Red fire compositions, for example, often consist of potassium chlorate, sulphur, antimony sulphide, and strontium nitrate, the latter giving the red color to the fire. Copper oxide is used to produce *blue* fires, while the chlorate or nitrate of barium is used for *green* fires.

Fire works intended to produce a projectile force usually contain gunpowder, sometimes in *admixture with potassium chlorate.* If an explosion accompanied by a loud noise is desired, granulated powder is often used. Fuses for fire works are generally made of cotton impregnated with gunpowder, while caps and detonators usually contain fulminates. It is important to note that the principal ingredient in most fire works is potassium chlorate, and it is, therefore, not surprising that most of the fire work mixtures found in use may be ignited by friction or percussion. Practically all of them may be ignited or exploded by heat. In the case of fires and explosions in buildings many of the fire works give off very irritating fumes, which render the work of extinction difficult.

Many of the compositions contain certain ingredients or impurities, which render the mixtures chemically unstable and liable to spontaneous ignition or explosion.

Guncotton. Guncotton $C_{12}H_{14}O_4(NO_3)_6$ is cellulose hexanitrate, for cotton is a fairly pure form of cellulose, $C_{12}H_{20}O_{10}$; we may, therefore, regard guncotton as a nitrate of cotton. It is manufactured by treating cotton, freed from impurities, with a mixture of nitric and sulphuric acids*. After nitration the cotton is washed with water until free from acids, for the presence of the least trace of acid may cause it to explode spontaneously.

$$C_{12}H_{20}O_{10}+6HNO_3=C_{12}H_{14}O_4(NO_3)_6+6H_2O.$$

Guncotton finds extensive use as an explosive either alone or mixed with other substances. A mixture of guncotton, nitroglycerin, vaseline, and acetone constitutes *cordite,* which is used as a smokeless powder. When mixed with nitro-glycerin and camphor the mixture is known as *blasting gelatine,* which is somewhat less dangerous than dynamite according to the camphor content.

When a small flame is applied to cool guncotton, it ignites and burns rapidly, usually without exploding. If it is heated gradually and a flame is then applied it may explode. Statements of observers differ widely as regards the temperature at which guncotton ignites; 160°C. is perhaps the approximate ignition point. Combustion of loose guncotton may occur without an explosion taking place. However, if all the particles of an explosive such as guncotton be raised to a temperature near their ignition point, the first particles which ignite may detonate the other particles. These conditions are liable to be fulfilled in a conflagration. Guncotton may be exploded by percussion. Even when wet or unconfined it may be caused to explode violently by detonating a fuse or fulminate of mercury in contact with it.

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*The sulphuric acid is added to absorb the water produced by the reaction. Hence, it prevents dilution of the nitric acid.

Celluloid (Pyroxylin). When cotton (cellulose) is treated with nitric and sulphuric acids for a short time only, the cellulose is converted into lower nitrates of cellulose, such as tetra-nitrate $C_{12}H_{16}(NO_3)_4O_6$, and penta-nitrate $C_{12}H_{15}(NO_3)_5O_5$. These lower nitrates in solution in alcohol are called *collodion*, and when in admixture with camphor so as to form a solid material, the product is known as *celluloid*. Celluloid also often contains the hexa-nitrate (guncotton), and many inert materials, coloring matters, etc. Hence, some celluloid is essentially a mixture of guncotton and camphor· while some is essentially a mixture of guncotton, camphor and the lower nitrates of cellulose.

Celluloid is a very inflammable material which ignites at a low temperature. 150°C. may be regarded as the approximate ignition point of most of the celluloid met with in practice. This temperature is not far above the boiling point of water. It is clear, then, that celluloid articles may be ignited by the radiant heat from a hot stove, steam boiler, or incandescent lamp. Celluloid is a compound containing carbon and oxygen ready, so to speak, to unite with each other; in other words, celluloid carries with it oxygen to help support its combustion. Hence, when it is ignited it burns *very rapidly*, evolving a great deal of heat, and if confined when burning it may cause an explosion.

Divergent views exist as to whether or not celluloid is explosive. The presence of the camphor tends to prevent celluloid from undergoing sudden decomposition. Methods of manufacture differ and the proportion of camphor in celluloid articles varies. The combustion of celluloid in the air produces principally carbon dioxide, nitrogen and water.

When the ignition of celluloid is effected in a confined space, so that decomposition occurs under pressure, certain of the products formed are different from those which result from the combustion under ordinary atmospheric pressure, and are capable of forming with the air explosive mixtures. In some cases the dangerous products formed under pressure are hydrogen and carbon monoxide. Celluloid is, therefore, capable of producing violent explosions in confined spaces.

Nitro-Glycerin and Dynamite. Nitro-glycerin, $C_3H_5(NO_2)_3O_3$, is an oily fluid. When pure it is colorless, but the commercial product is usually yellow or brown. It is prepared by treating purified glycerin, $C_3H_8O_3$, with a mixture of strong sulphuric and nitric acids. The sulphuric acid is added merely to take up water formed by the reaction:

$$C_3H_8O_3 + 3HNO_3 = C_3H_5(NO_2)_3O_3 + 3H_2O.$$

It is employed extensively as an explosive alone or in the form of *dynamite*, which is a mixture of nitro-glycerin and kieselguhr or other porous inert material. It is also used in admixture with guncotton for blasting and in the manufacture of smokeless gunpowder. It explodes with great violence when suddenly heated or when subjected to percussion. When ignited with a flame it commonly burns without exploding. It is not very easily ignited as it is not readily inflammable. When frozen, nitro-glycerin is more hazardous than when in the liquid state.

The presence in it of the least traces of acid renders it liable to spontaneous decomposition and explosion. Nitro-glycerin in the form of dynamite is somewhat less hazardous and safer to handle and transport. Dynamite should not be exposed to low temperatures. When frozen the dynamite is far more dangerous than when in the ordinary condition. Countless explosions are caused by improperly thawing dynamite.

It will be evident from the above, that of the explosives mentioned, fulminate of mercury is the most hazardous. Guncotton, dynamite, nitro-glycerin, cordite, and blasting gelatine are when pure dangerous only under certain defined conditions. While there seems to be no occasion for people who are not properly fitted to do so, handling such materials, it is a fact that persons who know next to nothing of the composition and behavior of explosives are often entrusted with their use and storage. It would also seem, in view of the fact that explosives containing certain impurities are very liable to spontaneous ignition or explosion, that no impure products of this nature would be placed on the market. However, as is well known, such impure products do find their way to the market and often cause serious explosions.

Acetylene. Acetylene is one of the most inflammable and explosive gases known. It has a very strong affinity for oxygen, the heat of combustion is high, and the explosive range is very wide. Acetylene is an endothermic compound, and is capable of decomposing into its elements, hydrogen and carbon; the decomposition is accompanied by the evolution of a great amount of heat. The heat evolved when decomposition occurs causes the gas to expand very suddenly with the result in many cases of a very violent explosion. It will be noted that the presence of air is not necessary for the explosion of acetylene by *decomposition.* When acetylene is under pressure, exceeding that of the atmosphere, the explosive risk is increased. Under such conditions the explosion may be produced by detonation. Acetylene, can, however, be successfully stored in solution in acetone.

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ASTOR, LENOX AND
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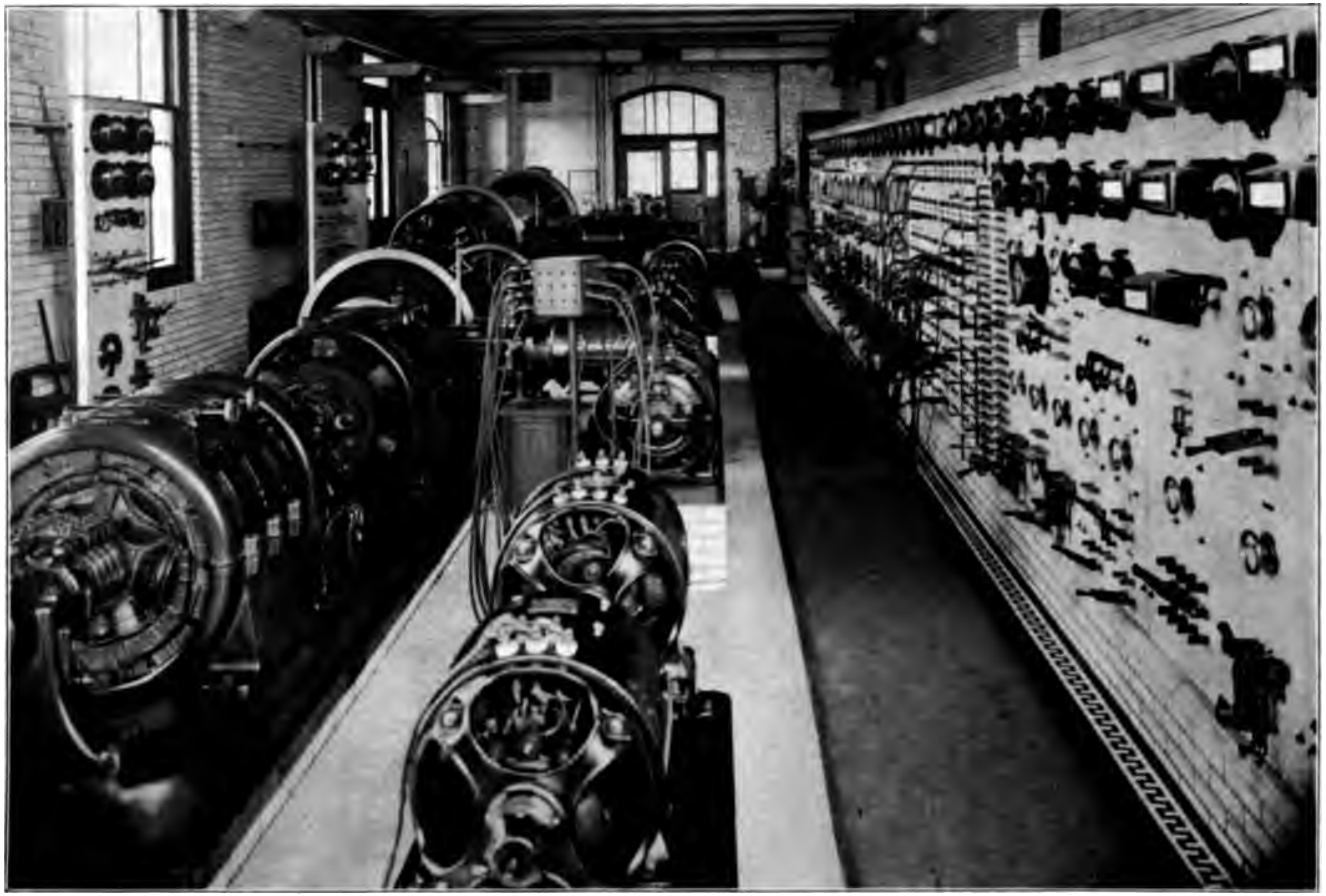

VIEW OF GENERATOR ROOM AND SWITCHBOARD, NATIONAL BUREAU OF STANDARDS
These Generators Supply All the Various Types of Current for Electrical Testing. Harmonic Alternator Set at the Left

UNDERWRITERS' REQUIREMENTS

PART I

INTRODUCTION

The insurance interests are concerned with electric work only **for the reason that** such work if done improperly constitutes a fire **hazard, and** underwriters' rules on electrical installations are, therefore, **confined** to such questions as concern proper methods and **materials** to be employed to minimize the chance of fire arising from **the use** of electricity for light, heat, and power. Electricity as **employed for** signaling work, such as telegraphs, telephones, call **bells, burglar alarms,** and similar purposes, is not covered by in**surance rules** except in so far as such installations may become dan**gerous because** of the liability of wires in such systems becoming **crossed with** electric light, heat, or power circuits.

The many applications of electricity for municipal fire-alarm **systems, factory** or isolated plant fire alarms, watchman's time-**recording** appliances, and automatic alarms employing electric **thermostats, are** not covered by the general rules for electric work. **They do not in general** tend to cause a fire hazard of themselves **but come rather** under the head of protective devices and the dis**cussion of them** does not, therefore, come within the scope of this **paper.**

The earlier installations of electrical lighting and power ap**pliances were** very crude and were often made with no considera**tion of what are** now generally admitted to be questions of great **importance from** the viewpoint of fire protection. It was natural **that experience** should have been necessary to demonstrate the **need of protection** against unreliable or hazardous methods of apply**ing electricity** and to develop improved materials and devices. **The comparatively** mysterious nature of electricity as viewed by **the general** public led at first to a habit, not yet wholly outgrown,

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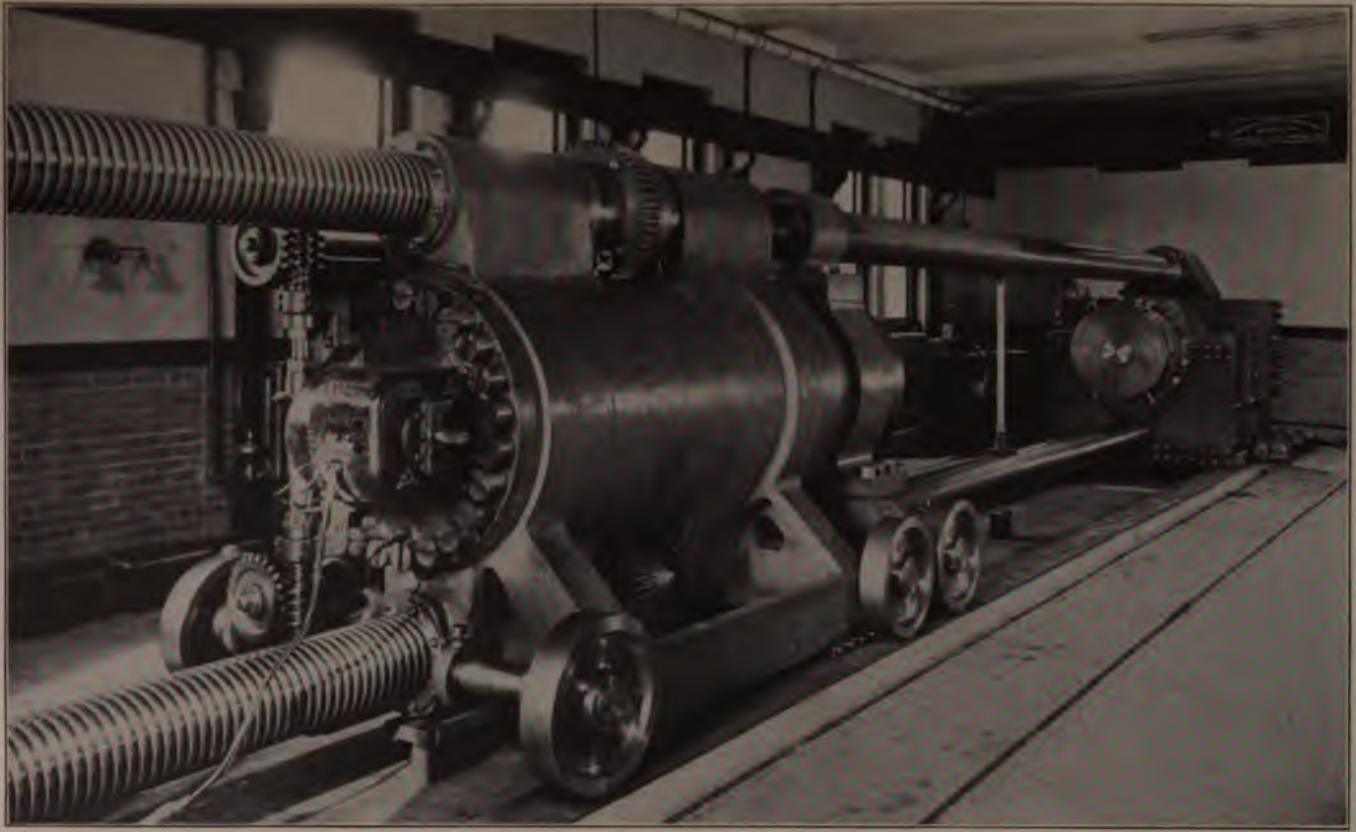
of attributing to electrical causes all fires for which no other cause was readily apparent. Today, however, the production of light and the transmission of power are without question accomplished more safely as well as more conveniently and economically by electricity than by any other means.

In judging electrical work as affecting the fire hazard, the fire-protection engineer and underwriters cannot undertake to do for the assured, the work which lies within the province of the electrical engineer on whom properly falls the responsibility of designing installations and choosing the methods and materials to be used to accomplish the results desired. In electrical, as in other engineering, consideration of first cost, economy of operation and maintenance, efficiency of machinery and appliances, depreciation, and reliabiiity are of prime importance. It is the proper function of the fire-protection engineer to act as critic of the plans and their execution in order that other considerations involved shall not be allowed to dictate methods which do not afford suitable and reasonably safe fire conditions. Electrical engineering is far too complicated a profession to be fully mastered by the fire-protection engineer or by an inspector, but the general principles of safe electrical work can be mastered and applied without presuming to encroach on the work of either the consulting or the installing engineers.

Architects are now very generally prepared to recognize the necessity of providing in their plans for the electrical installations which in more elaborate buildings must be given very careful attention if adequate provision is to be made for electric wires and appliances. It is in the smaller and less carefully planned structures that the electric work is most likely to be left to the installers to be put in as best it may. A well considered plan adapted to the type of building and the uses to be made of current is an essential to successful and safe work. Makeshifts are usually dangerous. For this reason, also, it is often much more difficult to secure proper electrical work in wiring old buildings than new ones.

Electrical contractors are usually willing to do good work for a fair price and most poor work is due to an attempt to secure business at too low rates in order to meet competition. Since a faulty or dangerous electrical installation may perform its appointed work, and since electrical defects are not easily discovered, often develop-



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ing after some time, only thoroughly good work from the start affords real protection against disastrous failure from causes which, after a fire, may be very difficult to assign but which might have been easily foreseen and removed.

Electrical inspectors either of the underwriters or of the municipality should be fully acquainted with approved methods, rules, reasons for rules, and must have a great range of practical knowledge which only actual field experience can give; and such inspectors must be specialists of a high order. The fire-protection engineer must refer to such specialists the technical details while undertaking himself to be a competent judge of general methods and principles.

Electricity as a Cause of Fires. Electricity may in general be the cause of a fire in either one or both of the following ways:

First: By causing wires, cables or other conductors to be overheated by the passage of the "electric current," thereby setting fire to the insulations on such conductors or to nearby combustible materials. All conductors are heated by any current however small, but if the conductor is badly overloaded it may become red- or even white-hot. Hence it becomes necessary to prescribe the safe carrying-capacity of wires, and all conducting parts of electric appliances must be properly proportioned. Such parts as are peculiarly liable to become heated or which must be heated to perform their proper function must be suitably protected and separated under all circumstances from materials which might be ignited.

Fuses, circuit breakers, and other automatic appliances have to be installed to afford protection in case of accidents which may result in conductors or other devices being overheated by abnormally large currents. Such protective devices may themselves become dangerous and the rules, therefore, prescribe carefully how they must be constructed and installed. Overheating of conductors is thus one of the two general ways in which electricity may cause a fire and provisions against such accidents, therefore, form an important part of the rules.

Second: Electricity may form "arcs." An arc is the visible evidence that the current is passing from one conductor to another or across a break or gap through the air or over the surface of an insulating material. An arc always causes heat and if any appreciable current passes, the arc will be very hot and if continued is capable of melting the adjacent metal at the gap or setting fire to any combustible matter near by. It, therefore, becomes necessary to prescribe rules, the observance of which tends to lessen the chance of accidental arcs being established, and to so locate all appliances, the operation of which produces arcs, that no harm will result. Switches, circuit breakers, and fuses are all "arcing" devices. The problem of insulation, spacing between conductors and excellence in materials, methods of installation and workmanship, all have to do chiefly with the prevention of accidental or dangerous arcs.

From the viewpoint of fire hazard, it is well to treat all conductors, however well insulated, as bare, and to proceed to furnish adequate protection against grounds or short-circuits on that basis.

In judging of installations it must constantly be kept in mind that conditions are liable to become worse rather than better after the wiring and appliances have been in use for some time. Requirements are, therefore, made to anticipate in part such deterioration as is inevitable in even the best equipments, and which may be surprisingly rapid when inferior materials are put in by careless workmen and used and abused by those having little or no understanding of electrical affairs and no appreciation of the hazards involved.

The following are the chief general requisites for a safe electrical installation: Excellence of material; simplicity in design so far as compatible with the results to be secured; ease of inspection and repairs of all wiring and appliances; thoroughly good mechanical execution of the work; the choice wherever possible of the more protected and safer forms of wiring; and the use of "approved fittings." No rules can take the place of good designing nor will perfunctory obedience of rules make a poorly executed job, safe. The architect, the owner, the manufacturer of devices and materials, the electrical contractor, the electricians who install and those who operate the plant—each and all must share the responsibility with the insurance and the municipal inspector.

Elementary Electrical Ideas and Terms. Electric power may be transmitted by either direct or alternating current.

Direct Current. Direct current is current of such character that what is usually called the "direction" of the current is always the same, or, more exactly, the magnetic effects of the current are not being reversed from instant to instant. If a small compass be held near a wire carrying direct current, the needle may be caused to turn away from its natural north and south line. Thus in Fig. 1, if *D* is a direct-current dynamo connected to a wire from south to north, a compass needle over the wire, before the switch *T* is closed, will point along the wire; when the switch is closed, if current flows as shown by the small arrows on the wire, the needle will turn as shown. The amount it will turn is an indication of the amount of current, but the needle will remain stationary in its new position if the current is direct current. A battery gives direct current and so does a direct-current dynamo.

Alternating Current. If, however, the current came from an alternating-current dynamo or from a transformer supplied by such a dynamo, the needle would tend to swing very rapidly first to one side of the wire, and then to the other. This would also be the case if the connections on the direct-current machine, Fig. 1, were rapidly exchanged back and forth. Such reversals of current direction are made automatically by an alternating-current dynamo. The number of changes per second is called the frequency and 25, 60, and 135 are the commonest commercial frequencies of alternators. Evidently no compass needle could actually vibrate so fast, but it *tends* to do so, and the result is that the needle does not appear to be affected by the alternating current.

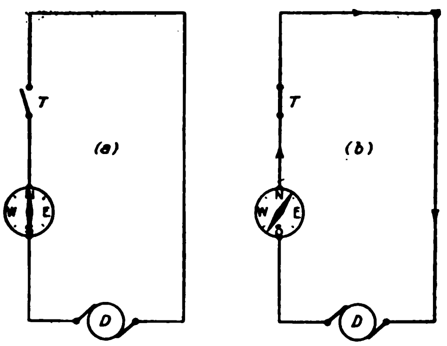

Fig. 1. Diagram of Simple Dynamo Circuit Showing Effect on Magnetic Needles

Both direct- and alternating-current systems are in common use for light and power. Street railways use at present chiefly direct-current systems. Where power must be conveyed to considerable distances, alternating current is used because it is more economical under these conditions. Different motors and somewhat different arc lamps are required for direct and for alternating circuits. Incandescent lamps are the same for either system as are also most heating devices. Transformers can be used only on alternating-current systems.

The distinction between direct and alternating current is not one which has many important consequences in the safeguarding of electrical work. There are, however, a few important cases where different rules are established. It should be remembered that direct and alternating currents of the same strength produce the same heating effect in a given conductor. In some cases, however, with alternating currents an additional heat effect is produced in certain appliances by the magnetic action of iron cores, of coils, or other parts of the apparatus. In general, alternating current produces less severe and persistent arcs than direct current of the same strength and voltage. Furthermore, alternating-current motors in particular are somewhat less liable to emit sparks and, therefore, have a certain advantage. As a whole, however, no distinction may be made as regards fire hazard between direct- and alternating-current installations which should be made with the same care in workmanship and with the same precautions as to insulations, fuses, and all protective devices.

Current. Current is measured in *amperes*. It may be compared to the number of "gallons per minute" carried by a water pipe through which a stream is flowing. More "current" will, other conditions being equal, do more work, and will always cause more heat in the conducting wires and cables and in the appliances, lamps, heaters, resistances, motors and the like which use the current. Furthermore, the heating effect in conductors such as metals varies with "the square of the current," *i. e.*, if one unit of current produces a certain amount of heat in a wire, *twice* as much current will cause *four* times as much heat in the same wire, *three* times the current will cause *nine* times the heat and so on. An instrument for measuring current is called an ammeter.

NOTE. The heat liberated is a measure of energy or power consumed in the wire. The *temperature* of the wire will not necessarily follow the rule given above, this being dependent not only upon the heat developed but also upon the surroundings of the wire as affecting the readiness with which the heat may be radiated or otherwise gotten rid of.

Voltage. Voltage or potential is measured in volts. *Volts* measure the propulsive force which causes "current" to flow through a conductor. It may be thought of as an electric pressure produced by the dynamo, battery, or other generator of electricity. Through a given circuit a higher voltage will in general cause a proportionally greater current. Since it is the voltage which may cause electricity to pass from its proper path and seek other and perhaps dangerous paths, higher voltages require better insulation on wires and in all electrical appliances. The voltage used thus becomes an important factor in determining the protection necessary for safety.

Difference of Potential. Two points, as on conductors or between a conductor and the earth, are said to be at *different potentials.* When such an electrical condition exists on them a current *tends* to pass between them either along the conductor or across a gap between the points. Along the conductor such a current produces heat, while if the current "jumps the gap" or *arcs*, heat is produced in the spark or arc formed.

Resistance. Resistance is measured in *ohms*. All substances offer resistance to the passage of current. This is true of metals, liquids, and gases. A good conductor, such as copper, has comparatively little resistance. Other materials, such as slate, porcelain, and rubber, are very poor conductors and may generally be considered as *insulators*. Since heat is always produced, the conductors must be of suitable size and material to keep the temperatures below the dangerous values, or, in cases where the heat is the result desired, suitable protection must be provided. The resistance of conductors is thus a necessary but undesirable property in some ways and a usable and valuable property in others. In all cases the fact that current produces heat in conductors must be reckoned with in electrical problems.

The loss of power from the heat expended in a supply wire is an illustration of the undesired property of resistance. The electric flatiron is an appliance where the resistance produces a useful result.

Ohm's Law. For our purpose here the relation between current, voltage, and resistance in a direct-current circuit may be stated as follows: The current (amperes) in a circuit equals the voltage (volts) divided by the resistance (ohms), or $I = \frac{E}{R}\cdot$ This is true both of entire circuits and parts of circuits, provided E and R are the voltage and resistance of the whole circuit or the part under consideration, respectively. For a. c. circuits a somewhat more elaborate formula must be used.

Power. Power is measured in *watts.* (A kilowatt is 1,000 watts.) In direct-current circuits the power expended in any portion of the circuit is obtained by multiplying the current in amperes by the voltage across the portion of the circuit. Thus: If the current in an incandescent lamp is ½ ampere and if a voltmeter shows that the voltage across the lamp terminals is 110 volts, the power is 55 watts.

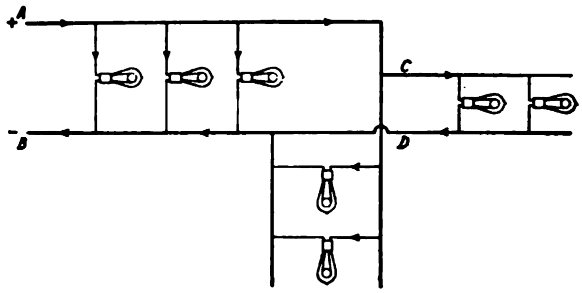

Fig. 2. Parallel Lamp Circuits

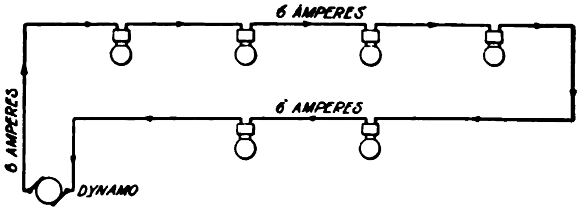

Fig. 3. Series Arc-Lamp Circuits

The corresponding mechanical term is horse-power; 1 horse-power is equivalent to 746 watts and 1 kilowatt equals about 1⅓ horse-power. With alternating current the power in watts is not always to be obtained by multiplying amperes by volts. With alternating currents, a third factor must be used, called the "power factor" of

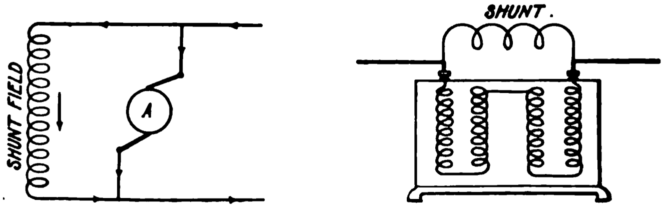

Fig. 4. Diagram of Shunt Circuits

the circuit. It is sufficient for our purpose here to remember that the power actually delivered and used with alternating current *may be less* than the simple product of amperes and volts. Thus, if a current of 50 amperes as read by an ammeter, passes through a coil of wire, and the voltage across the terminals of the coil is 100 volts, the power consumed, if the current is direct, is 50×100=5,000 watts or 5 kilowatts. If, however, the coil surrounds an iron core (as in an electromagnet) and alternating current is used, the power consumed will not be 5 kilowatts. The power factor may be 60 percent for this coil, and the power consumed will then be 50×100× .60=3,000 watts or 3 kilowatts, instead of 5 kilowatts. The following definitions will be useful to those unfamiliar with electrical terms.

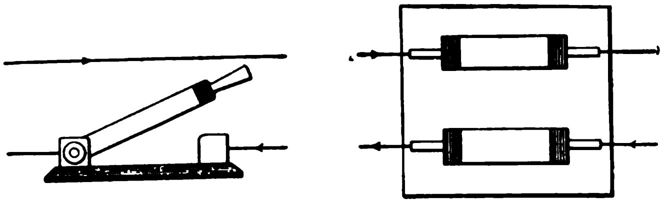

Fig. 5. Single-Pole Switch and Double-Pole Fuses

Multiple Connection. When a number of devices such as lamps, motors, etc., are so connected that the current has a path through each device separately from one supply wire to another, they are said to be connected in *multiple*. See Fig. 2. Incandescent lamps are almost always connected in multiple. In Fig. 2 if each of the 7 lamps shown takes 1 ampere of current the total current at *A*

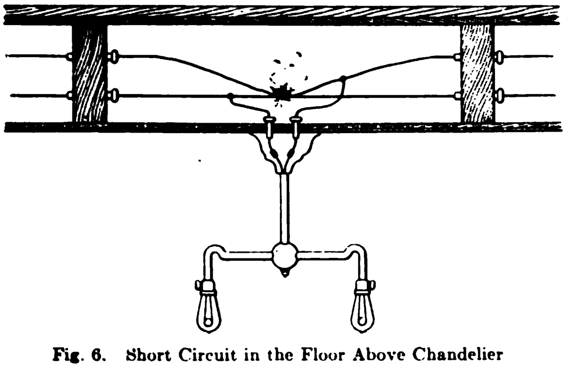

Fig. 6. Short Circuit in the Floor Above Chandelier

and at *B* will be 7 amperes, while at *C* and at *D* it will be 2 amperes.

Series Connection. When a number of devices are so connected that they come one after another, they are said to be connected "in series." In Fig. 3, the arc lamps are shown so connected. In this case the same current traverses all parts of the circuit and the total current is no more and no less than the current in each connected series device.

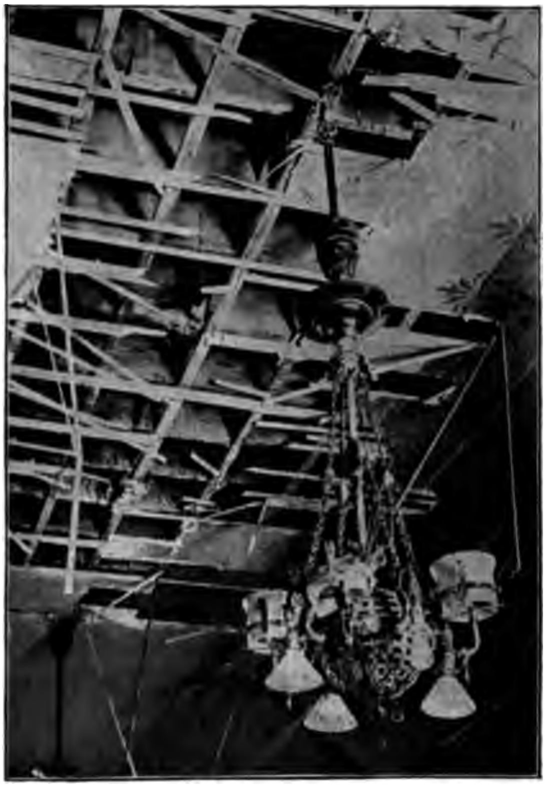

Fig. 7. Effects of a Short-Circuit in Wires Under Floor

Shunt. A shunt is a by-path between two points so connected that part of the current will traverse it. The division of the total current between the main path and the shunt will depend on the comparative resistances, the larger current going by the path of lower resistance. In Fig. 4 are shown the connections of a "shunt motor" and resistance box "shunted" by a wire.

Cut-Out. A cut-out is a device for automatically breaking a circuit, usually when the current reaches a predetermined value. Thus, a 60-ampere fuse is a cut-out designed to burn out when currents in excess of 60 amperes pass through it. A circuit breaker is an electro-mechanical switch which is also used as a cut-out.

Switches, fuses and other appliances are said to be *single-pole* if they are for but one wire of a circuit; *double-pole* if for two, *triple-pole* if for three. Fig. 5 shows a single-pole switch and a double-pole fuse.

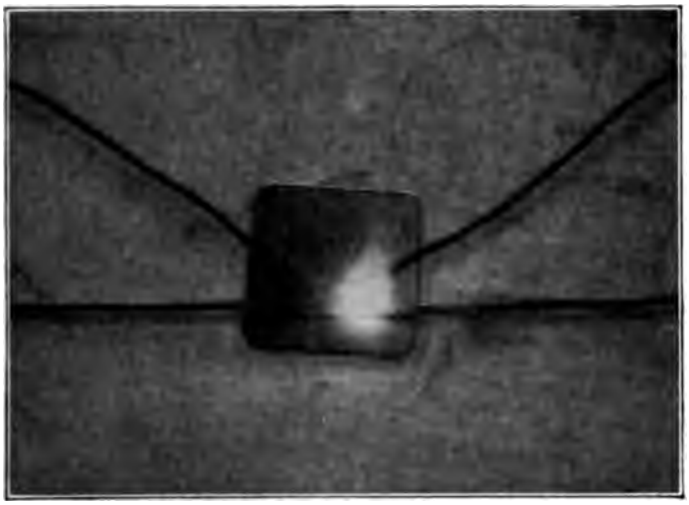

Fig. 8. Arc Between Wires of 250-Volt Circuit

Ground. A ground is a connection either intentional or accidental between a part of an electric circuit and the earth, or any metal or other conducting substances which are in electrical connection with the earth, such as water and gas pipes, iron beams, etc.

Short-Circuit. A short-circuit is a connection which permits current to flow from one part of a circuit to another by any path which it is not intended it should take. Since such a connection is the result of accident or the failure of some insulation, and since it usually allows excessive currents to flow, a short-circuit may be very dangerous and liable to cause a fire, especially as the accidental connection may afford very poor contact and cause arcing and burning at the junction of the conductors. Fig. 6 illustrates a short-circuit in a floor between the two supply wires to a chandelier installed on the ceiling below. The effect of this short-circuit is shown in Fig. 7. Fig. 8 is from a photograph of an arc produced by a 250-volt ampere current between two wires which were touched together at a point where the insulation had been destroyed.

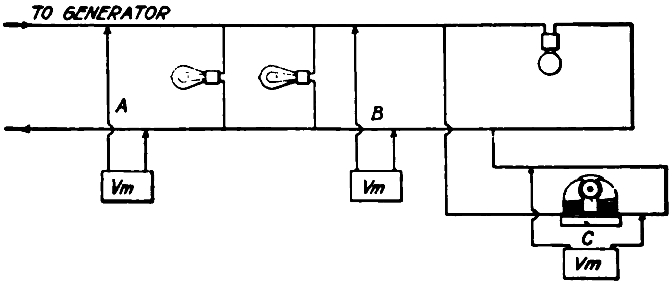

Fig. 9. Diagram of a Constant-Potential System

Constant-Potential System. A constant-potential system is one in which the voltage between the main supply wires is approximately the same at all points. Such a system is supplied by a constant-potential generator, which is of a character to furnish greater current as more devices, lamps, motors, etc., are put into use. Most in-

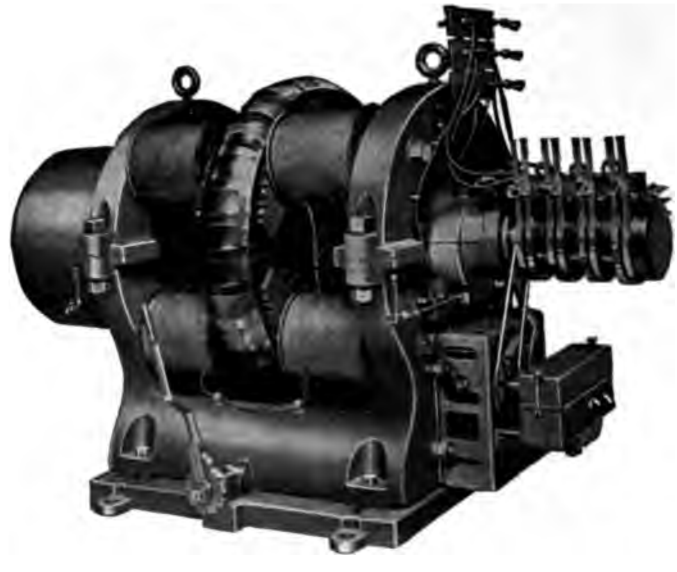

Fig. 10. Series Arc-Lamp Generator

candescent-lamp, motor- and street-railway circuits are of this type and also many arc-lamp circuits. Fig. 9 shows such a 110-volt system and if the distributing wires are properly chosen the voltmeters at the points *A B* and *C* will all read approximately 110 volts. Devices on such currents are connected in multiple.

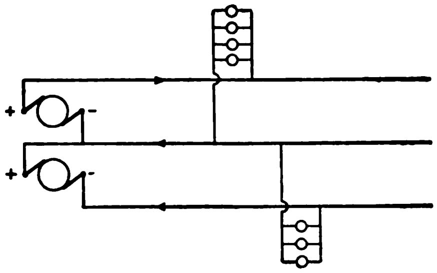

Fig. 11. Diagram of a Three-Wire Circuit

Constant-Current System. A constant-current system is one in which the current is automatically maintained approximately the same regardless of the number and character of the power-consuming devices in use on the circuit. Devices, usually arc lamps, are connected in series and the generator is of a type which automatically increases the voltage or electric pressure as more lamps are turned on. Fig. 3 shows such a circuit and Fig. 10 is a picture of a generator used for series arc-lamp work.

Two-Wire System. A two-wire system is one having a single pair of distributing wires.

Three-Wire System. A three-wire system is a special form of a multiple system usually employing two generators. Fig. 11 shows such a system with two-wire branches to incandescent lamps.

Transformers. The chief advantage of alternating over direct current lies in the fact that electric power can by alternating current be transmitted at a *high voltage* from the generating station to the point where the power is to be used, and there *transformed* with small loss to a voltage better suited to motors and lamps.

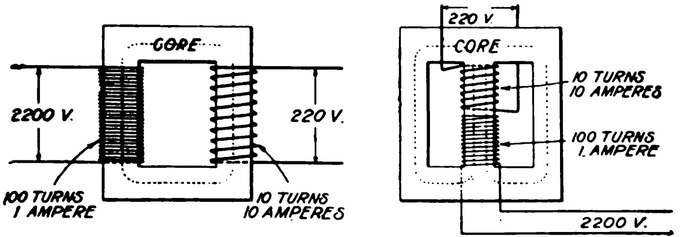

Fig. 12. Diagram of Two Types of Transformer

It is far more economical to transmit power at high voltages. It can be shown by electrical theory that by using twice as high voltage, a wire only one-fourth as large is needed to transmit a given amount of power with the same percentage of loss on the transmission line. It should be remembered that if the voltage is doubled the current need be only half as great in order to have the power delivered the same. But half as much current heats the wire which carries it only one-quarter as much and, since the heat dissipated on the wire is lost power, it is evident that economy requires that transmission of electric power be accomplished by high voltage and relatively small currents rather than the reverse. Thus it may be commercially possible to utilize a water power at a distance from a city to make high-voltage current which can economically be transmitted to the city over a line of rather small copper wires. It would never do, however, to carry this high-voltage current into buildings on account of the great fire risk involved, for the insulations in wiring cannot be made safe for high voltages. With direct current there is no very economical way to change a small current at high voltage into a larger current at a lower and safer voltage. With alternating current, however, this can be done very readily by means of a "transformer," a device which consists in its simplest form of two entirely separate coils of wire wound on the same iron core; in fact, a sort of double-coil magnet.

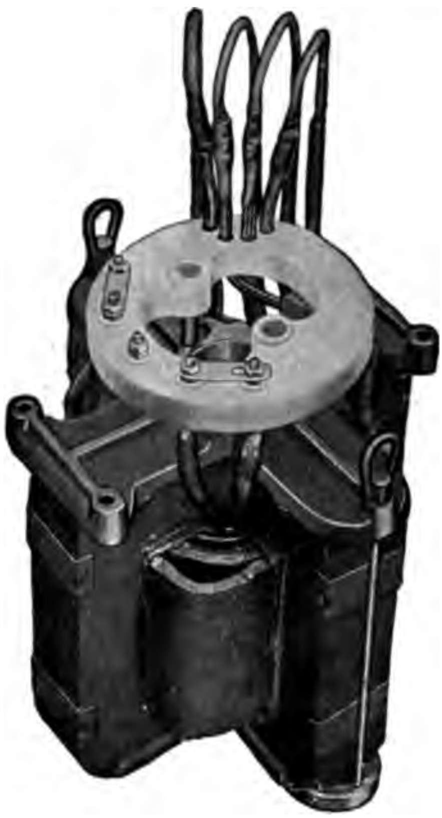

Fig. 13. Interior View of Incandescent-Lighting Transformer

Fig. 12 shows two shapes which a transformer may take. In each diagram suppose an alternating current at 2,200 volts and 1 ampere is supplied to one coil of 100 turns. Then a current of 220 volts and 10 amperes will be induced in the other coil which has but 10 turns, that is, the voltage will be "stepped down" in the same ratio as the number of turns on the *primary* (power-supply) coil and *secondary* (power-using) coil, and if there were no power loss in the transformer itself, the current would be multiplied by the same ratio inverted. In the case illustrated there are one-tenth as many turns in the secondary coil as in the primary and, therefore, the secondary voltage will be $\frac{2200\times 1}{10}=220$ volts, and the secondary current will be approximately ten amperes for every ampere supplied to the primary. If the power were supplied to the coil of the transformer having few turns, and used by the current induced in the coil having more turns, we should have a "step-up" instead of "step-down" transformer.

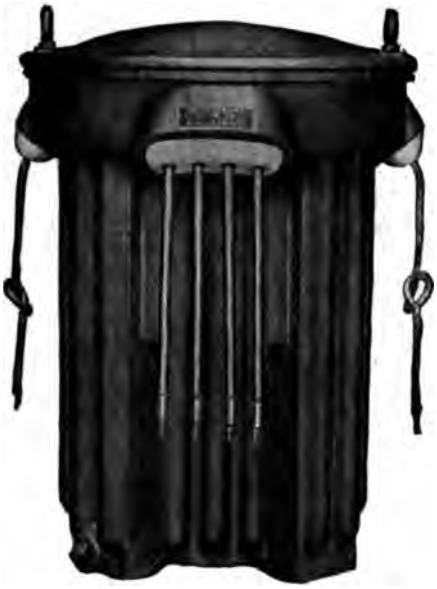

Fig. 14. Exterior View of Incandescent Lighting Transformer

It should be especially noted that the action of a transformer depends wholly on the principle that the rapid changes and reversals of current in one coil will induce currents in the other coil. Alternating currents are rapidly and systematically changing and reversing currents, and thus transformers can be used to change the voltage and currents in a. c. circuits. Direct currents do not change in amount and direction and, therefore, transformers cannot be used at all on direct current.

Figs. 13 and 14 show the interior and exterior views of a small transformer of a type used for incandescent lighting. The case is designed to be filled with oil. Transformers are constructed of all sizes up to very large units, and are cooled either by air, air blast, oil, or by forced circulation of oil through the windings and core.

Alternating-current dynamos and transformers are constructed and connected in several ways which differ in regard to the number of partially independent circuits which they supply. An a. c. circuit in which there are but two wires from the generator to the transformer or to lamps or motors is called a *single-phase* circuit. Fig. 15 shows the path of the current in a single-phase circuit which includes a generator *G*, switchboard with ammeter *A* and voltmeter *V*, transformers *TT* supplying power to lamps *L* and single-phase motor *M*. Single-phase circuits are used for lighting, both incandescent and arc, and for power.

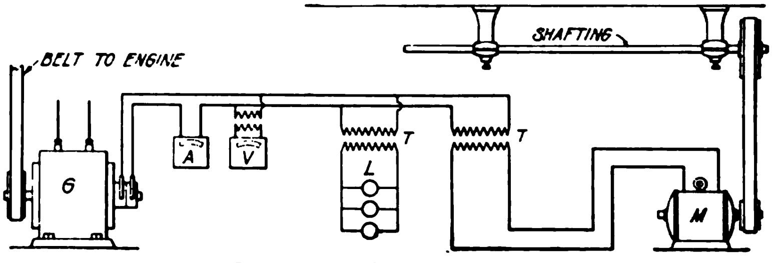

Fig. 15. Diagram of Single-Phase Light and Power Circuit

The other most common type of a. c. circuit is called *three-phase*, and is also used both for light and power. The essential parts of such a system are shown in Fig. 16 where it will be noted that the dynamo has three slip rings, the circuit has three wires and the transformer has three coils in the primary T_1, and three in the secondary T_2. In a three-phase circuit each pair of wires carries what may be considered a separate alternating current which varies in each pair in regular cycles, so that the maximum current in each phase or pair of wires is reached at different instants of time. Such circuits are very widely used, especially for power, with what are known as three-phase induction motors.

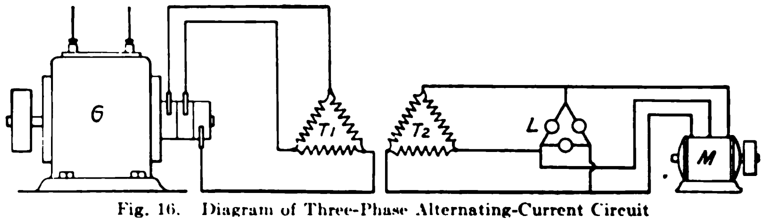

Fig. 16. Diagram of Three-Phase Alternating-Current Circuit

Essential Parts of Electric Installations. For the general purposes of this book the essential parts of electric installations are as follows:

Generators. Generators include all dynamos and storage batteries. These present the hazards inherent in all machines of any sort which produce or transform large amounts of power.

Cables. Cables and wires used for transmitting electric power are of concern from a fire viewpoint because of the possibility of their becoming overheated by the current, and because failure of the means provided to confine the electric current to them, namely, insulation, may give rise to arcs, *i. e.*, flames from powerful electric sparks or discharges. The rules for safe wiring, therefore, are designed to limit currents on wires to safe values and to insure integrity and reliability in the insulations employed.

Closely associated with the conducting wires and cables are those devices which serve to regulate the amounts of current, to open and close electric circuits, or to change the characteristics of currents at or near the apparatus utilizing the power. Of this sort are *rheostats*, *switches*, *voltage-regulators*, *motor-generator sets*, *rectifiers*, and the very common *alternating-curre t transformer*. All these must have suitable insulation and mechanical protection, and there must be due protection from the heat or arcs which may be produced in them.

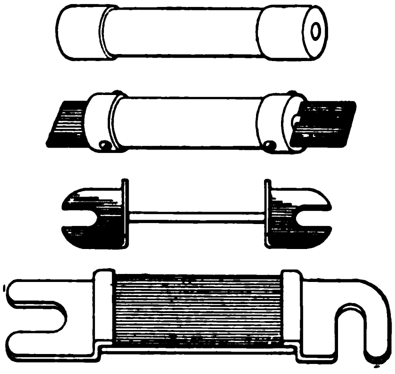
Fig. 17. Forms of Fuses

Power-Consuming Devices. The utilization of electric power, as of all power, is always accompanied by the production and dissipation of heat. Power-consuming electric appliances such as motors; all lamps, both arc and incandescent; heaters; and every other appliance using electric current, are, therefore, heat producers to a greater or less extent and must be so treated by the fire-prevention engineer.

Protective Devices. Protective devices are the safety valves of electric circuits. A fuse, Fig. 17, is a portion of an electric circuit purposely made so that it will melt and open the circuit when the current rises to a value which creates dangerous conditions in other parts of the line. The proper design and use of fuses thus involves the two questions of suitable protection to the wires and appliances, and the liability of the fuse itself to cause a fire when it operates.

Circuit Breakers. Circuit breakers, Fig. 18, are automatic switches arranged to open the circuit if currents reach too great values. They thus accomplish mechanically the same results as fuses. As a general principle it may be remembered that high-voltage circuits are more hazardous than low-voltage circuits, because they are more able to injure insulations and to produce arcs across gaps or from one wire to another. Large currents are not more dangerous than small currents so long as they have proportionally larger wires to carry them. In case of failure, however, large currents (many amperes) will cause more trouble. The persistency of an arc and the difficulty of suppressing when once started, are dependent upon both the voltage and the current (amperes), but it is the voltage which causes arcs to form, as across air gaps or by puncturing insulation on a cable.

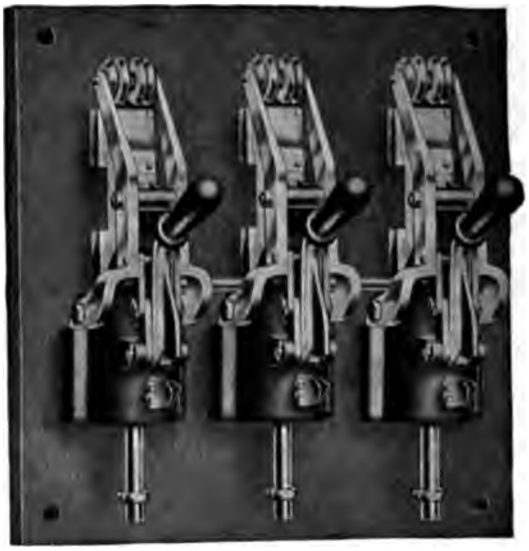

Fig. 18. Automatic Circuit Breaker

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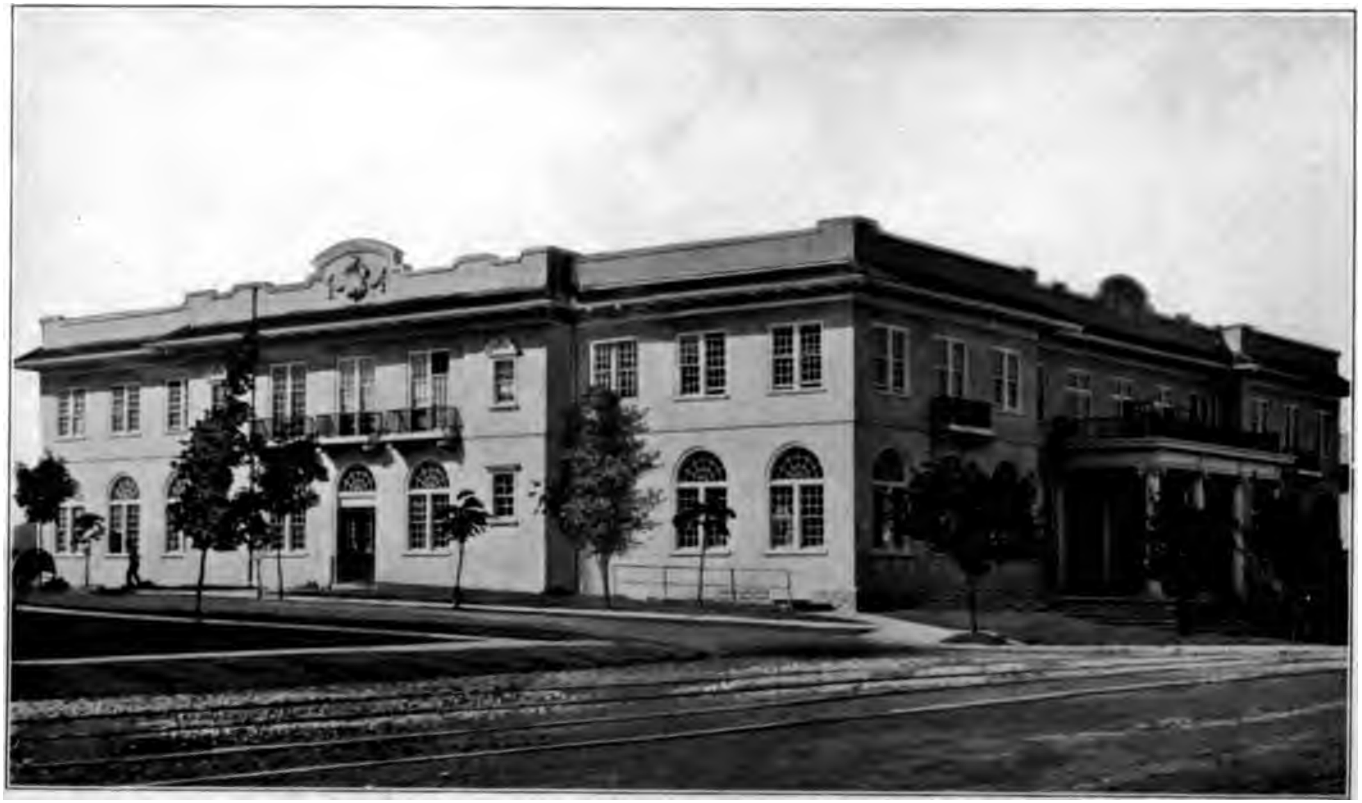
ASTOR, LENOX AND
TILDEN FOUNDATIONS.



TILE AND CEMENT HOTEL OF PLEASING DESIGN

Fireproofing Does Not Necessarily Destroy Artistic Effect. The Walls Are of Natco Hollow Tile Covered with Cement and Waterproof Paint. The Main Cornice Is Trimmed with Red Tile.

C. E. Urban, Lancaster, Pa., Architect. Courtesy National Fireproofing Company, Pittsburgh

The production, transmission, and use of energy are necessarily attended with certain hazards which are in a sense proportionate to the amount of energy employed. The peculiar property of electrical energy is that a failure or accident to electrical appliances often permits a large amount of energy to be suddenly expended in a very short space of time, as at an arc or short-circuit, and great heat is, therefore, developed.

NATIONAL ELECTRICAL CODE

As the result of the united efforts of insurance, electrical, architectural, manufacturing, and allied interests, there has been developed a comprehensive body of rules governing electrical work. The development and experience leading to these rules covered many years, but in 1897 what is known as the National Electrical Code*, was first issued by the National Board of Fire Underwriters with the approval of a large number of engineering associations of national scope, whose endorsement has given to these rules a standing and reputation unequaled by that of any other body of rules on an engineering topic in this or other countries.

The Code is generally admitted to represent the best opinion on electricity with relation to the fire hazard under the conditions existing in the United States. It is in general use by insurance companies, rating and inspection bureaus and departments, and engineering organizations. It is either adopted unchanged as the official body of rules for cities, or is, in some cases, used as the basis for the rules prescribed by the city government with a few changes or additions which are demanded by peculiar local conditions or which give greater protection against injury to persons than can be prescribed by insurance companies, which are, of course, not primarily concerned with the life hazard. These changes are, in nearly every case, of minor importance and consist usually of certain more stringent requirements than have found acceptance as a part of the Code. Few, if any, city rules are less exacting than the Code and nearly all are identical with its provisions.

It should be noted, however, that the Code does not attempt to prescribe the most efficient or economical means of applying electric currents, nor does it formulate engineering rules or practice, except in relation to fire hazards. It is published every two years following a public meeting in New York City at which all proposed changes or additions are thoroughly discussed. These meetings are held under the direction of the Electrical Committee of the National Fire Protection Association, a society the active members of which are insurance boards and bureaus, electric and architectural associations and institutes and other societies of national character. The Code has, therefore, the authority not only of underwriters, but also the indorsement of all the chief associations in the electrical and building industries.

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*The National Electrical Code will hereafter be referred to as the "Code."

Twice every year (April and October) is issued the *List of Electrical Fittings* which gives, under the names of manufacturers, the devices which have been approved for use after samples have been examined and tested in accordance with the *Construction Rules* by Underwriters' Laboratories, an institution located in Chicago, Illinois, and maintained by insurance interests for the purpose of making investigations having a bearing on the fire hazard.

In the pages which follow, no attempt will be made to restate *all* of the rules of the Code, but rather to indicate the chief underlying principles of the rules and explain some of the reasons for them.

Copies of the Code can be obtained without cost from any insurance bureau and reference to the Code will be made freely in this book. It is, therefore, assumed that the reader has the Code before him and will refer to it for the official statement of the several rules, and for the relatively less important details not repeated in this text.

POWER STATIONS AND THEIR EQUIPMENT

There are some peculiar hazards present in stations or rooms used for generating electricity aside from those always involved where larger amounts of power are produced and controlled.

In the case of companies furnishing electricity for light and power, the generating and transforming stations are often of large size, and contain apparatus which is very expensive and also of enormous importance for the uninterrupted maintenance of the service they render. Modern practice, therefore, tends toward the housing of such central plants in separate buildings of strictly fireproof construction, and the employment of every resource of engineering skill and experience to prevent fire from causing loss, either by the destruction of the equipment, or by interruption of service resulting therefrom.

The protection against fire in such stations thus becomes one of the chief considerations in the design of the whole plant and passes, therefore, in great measure into the field of the designing engineer. In any modern, well-designed central station the original equipment is usually fairly good from the viewpoint of fire hazard. The chief troubles often result from crowding equipment when it is found necessary to enlarge the capacity of the plant. Ample room for operating and for inspecting is absolutely essential. Accessibility of all portions of electrical equipment, the use of fireproof materials throughout, the installation of protective devices of approved design, and of ample capacity and arrangements, by which any trouble may be readily confined to a limited portion of the equipment, are chief requisites of a central-station equipment from the viewpoint of the electrical fire hazard.

Standard methods of installing generators, switchboards, and all transforming devices, should be followed, but the engineering requirements of special cases and the complexity and variety of such equipments in present-day stations render it manifestly impossible to describe in definite terms the details of construction and installation. In general, generators and motors of themselves present less hazard than the switchboards with the mass of wiring often found on them, the transformers with their charges of inflammable oil, or the large conductors carrying heavy currents and presenting large surfaces of combustible insulations.

Strict compliance with all accepted rules for wiring is of as great importance in central stations as elsewhere, both because of the large values involved, and because of the large amounts of energy to be controlled on the circuits. Central stations, therefore, should never be considered as outside of "Code rules" so far as they apply.

Generators. Generators for either central stations or isolated plants should always be located in a dry, light place as the presence of moisture is apt to injure the machines or may in extreme cases cause short-circuits in leads to the machine. No combustible material should be permitted near a dynamo, and it is desirable that there should be good ventilation to maintain reasonably low temperature, thus increasing the capacity of the machine.

The presence of generators in rooms where any hazardous process is carried on is not to be allowed and it should be remembered that sparks from generator brushes or rings may readily set fire to inflammable gases or to flyings of lint. Generators should be raised above the floor and should preferably be mounted on wood bases (Fig. 19) which insulate the machine frame. Such insulation will prevent a failure of insulation in the machine windings from grounding the system. Such a ground might cause a short-circuit if the system became grounded at another point. If the frames are not insulated a reliable ground connection is required in order to give a *good* path for any leak currents which may occur, instead of an accidental path which may be dangerous.

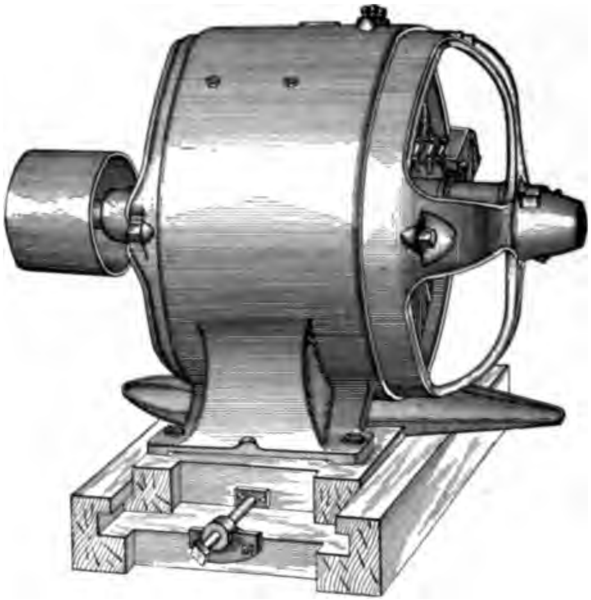
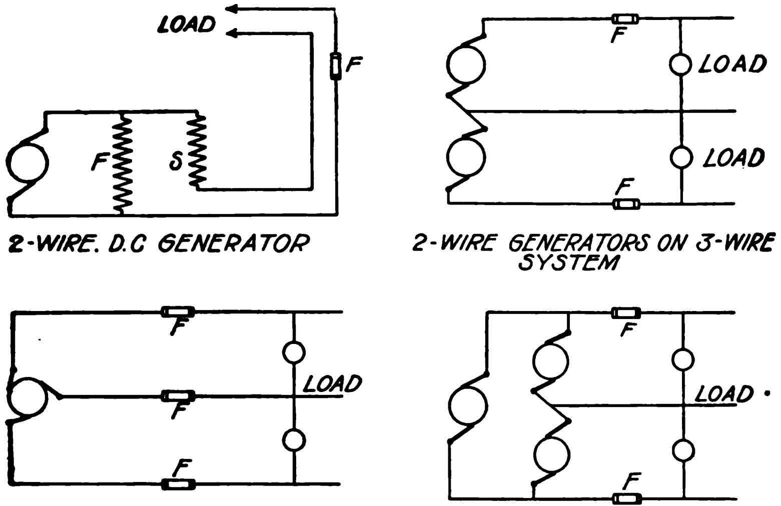


Fig. 19. Generator on Wooden Base

In generating plants supplying current to railway power lines, such as trolley and third-rail equipments, the current usually is carried to the trolley or third rail and returns after passing through the car motors by means of the track rails and the ground. All feed wires from such generating stations must be protected at the station by an approved circuit breaker or similar device which will automatically cut off the current from the feed wires in case of an accidental ground which might allow abnormally large currents to pass over the wire.

Dynamos in manufacturing plants are usually installed in the same rooms with the engines which drive them, and such rooms, therefore, present possible hazards from the exposure of wiring to steam piping and to mechanical injuries from whatever work may be done in repairs or alterations of machinery. The most common faults in such locations arise from crowding the electrical equipment into too small and inaccessible locations from a desire to use space either not available for other uses or not especially planned for electrical apparatus. Convenience of operation, cleanliness of surroundings, and a workman-like layout of equipment, all contribute to the maintenance of good fire conditions. The requirements for overload protection at constant-potential generators are shown in the diagram, Fig. 20, where *F* in each figure represents the fuses or circuit breakers required by the Code. These fuses and breakers will usually be located on the main switchboard. This leaves



2-WIRE. D.C GENERATOR

2-WIRE GENERATORS ON 3-WIRE SYSTEM

2-WIRE GENERATOR ON 3-WIRE SYSTEM

MOTOR-GENERATOR BALANCER

Fig. 20. Diagram Showing Fuse Protection in Various Types of Circuits

the large main cables from generators to switchboard unprotected and for this reason special pains should be taken with their installation since an accident to them might be very serious.

Dynamo-Room Wiring. All wiring in dynamo rooms should be done in the most substantial manner, and special attention should be given to simplicity and orderliness of arrangement. All supports for conductors must be very substantial. Fig. 21 shows an excellent example of a large mass of wiring well installed.

All wiring should be readily renewable and accessible. This usually requires either open wiring or some form of conduit. A fiber conduit is largely used for this work and gives good results. The large amount of wire and cable often found in dynamo rooms, together with the large currents carried on the conductors, makes it necessary especially about switchboards to cover the highly inflammable rubber and braided coverings with a tight jacket of some non-combustible material, such as asbestos, to reduce the probability of fire spreading rapidly over all the exposed wiring.

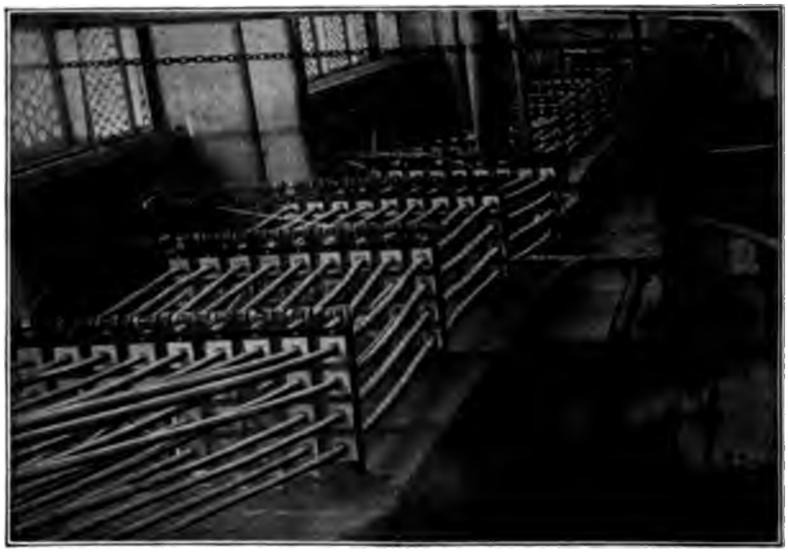


Fig. 21. Example of Large Mass of Wiring Well Installed

Bus bars are usually left bare but there should be as little other bare current-carrying metal as possible.

All conductors should have ample current capacity, and in their installation special care must be given to securing excellent insulation and reliable supports. Due regard should be given to the possibility of injury to conductors by tools, belts, ladders, etc., or by any vibration which may cause a gradual wear on wire coverings.

In general, the requirements of Class C of the Code apply to dynamo-room wiring with such special precautions as are dictated by the large currents to be cared for and the presence of a great number of conductors which may have to be placed rather closely together.

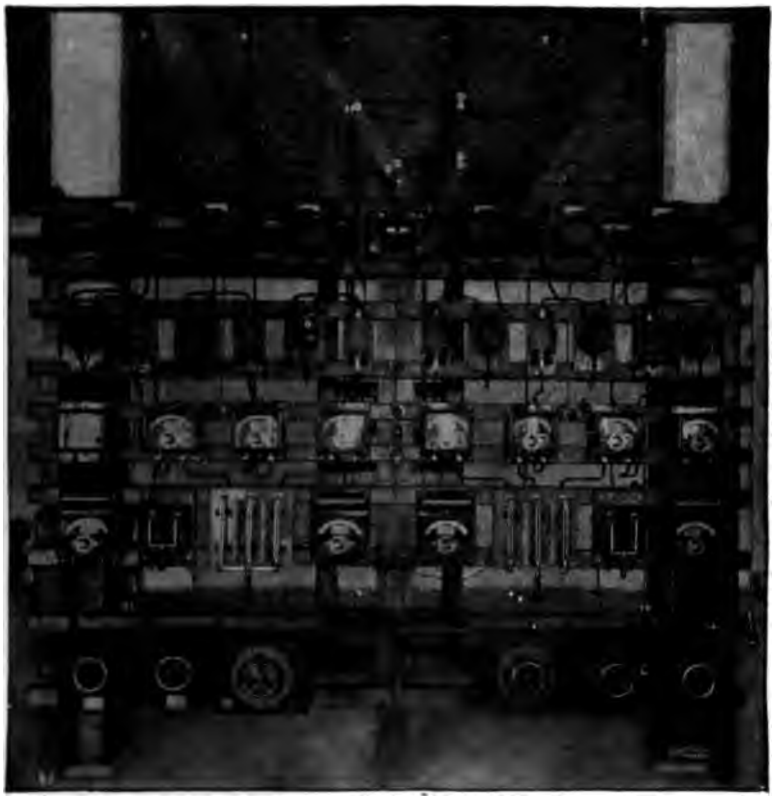


Fig. 22. Old-Style Type of Wood-Frame Switchboard

Switchboards. The danger of fire at switchboards lies in the large number of wires usually concentrated on them, and the use of rheostats, fuses, and other appliances which are possible sources of fire. The switchboard itself should always be of slate or porcelain.

The old wood racks (see Fig. 22) once used are not desirable though still permitted if of hard wood well filled. Fig. 23 shows a small, well-arranged switchboard. While the front of the switchboard is the operating side, the rear is the part where trouble is more likely to occur. The back of the board should, therefore, be easily accessible and neatness of arrangement and reliable supports for all conductors be imperative. No makeshifts are tolerable on switchboards under any conditions. Fig. 24 shows the back of a board. Every precaution must be taken to keep water or even moisture off switchboards since a short-circuit would be easily started and the result would often be highly disastrous. The Code, Rule 3, gives in detail some requirements for location and care of switchboards, the reasons for which are apparent without further explanation. Fig. 25 shows a large modern switchboard. In general the exact arrangement of parts on switchboards is determined by en-

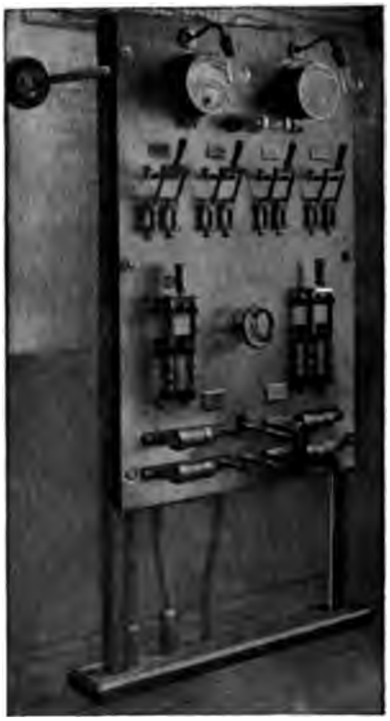


Fig. 23.* Approved Type of Small Switchboard.

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* *Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.*

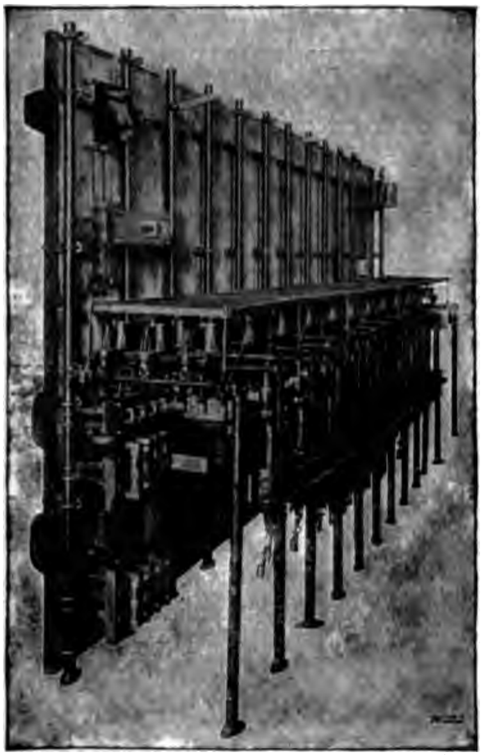

Fig. 24. Back View of Well-Arranged Modern Switchboard

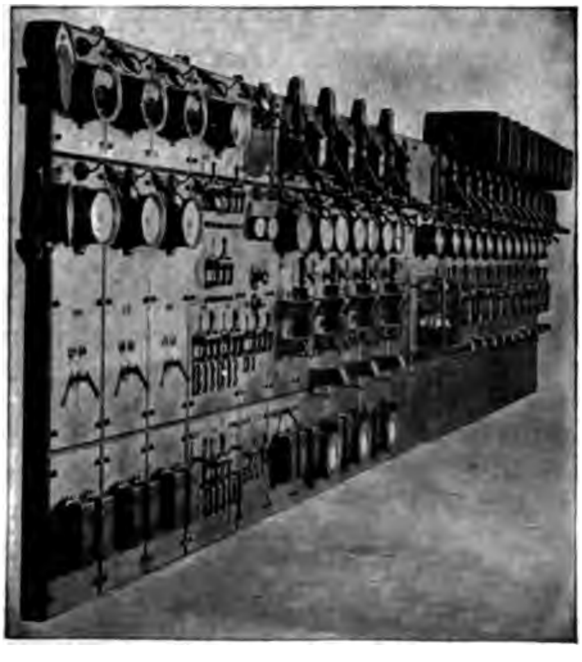

Fig. 25. Front View of Large Modern Switchboard

gineering and operating requirements, and the interest, from the viewpoint of fire, centers in the protection of conductors and the location of board and instruments to reduce the probability of fire spreading from the board to the other parts of the building. Orderliness and cleanliness should be insisted upon.

Resistance Boxes or Rheostats. These are used in a great variety of sizes and designs with dynamos and motors and at switchboards. They may be mounted either on the machines or switchboards or separately, but in every case they must be considered as "stoves" and liable to become "red-hot." The fact that they do not become hot when used under normal conditions is not to be considered as in any way lessening the requirements for protection.

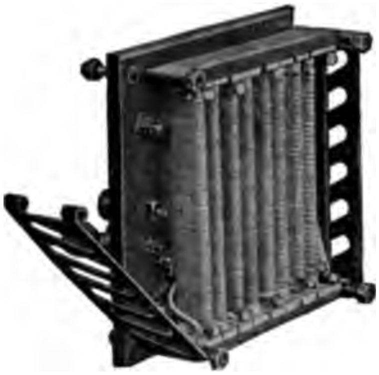
Fig. 26. Interior View of Small Starting Rheostat

A burn-out of a rheostat may result in a mass of flames from the numerous wires, usually contained in or leading to the device, and there may be drops or spurts of melted solder or other metal. Fig. 26 shows the interior of a small starting rheostat.

All resistance devices used for starting, regulating, and controlling machines are to be classed as "resistances" in the intent of the Rules, and so in general are all devices or parts of devices where coils of wire, iron grids, or other similar objects are made parts of the circuit.

Lightning Arresters. The purpose of these devices is to prevent lightning, or external high-voltage currents from foreign circuits, entering the station and there causing fire or damaging machinery and instruments. Lightning cannot be "stopped" but may be *diverted* to the earth. A large variety of lightning arresters are on the market but they are all designed to afford a path by which discharges may pass to "ground" instead of into the station apparatus and to prevent so far as possible the normal currents on the lines from following this path. The operation of many lightning arresters is accompanied by sparks which may in severe cases assume the size of powerful arcs. The location of these devices away from all combustible material is thus imperative. They are often installed in separate buildings with other emergency appliances.

The full discussion of lightning-arrester construction, operation, and installation is impracticable in this book. Suitable location, the running of connections in straight lines with the fewest possible bends, the use for ground wires of copper wire not smaller than No. 6, and especially the securing of permanently good ground connections are the chief considerations. Two separate ground connections are often desirable. Fig. 27 shows a type of electrolytic lightning arrester for 7,000 volts maximum potential to be used on three-phase circuits, grounded or neutral service.

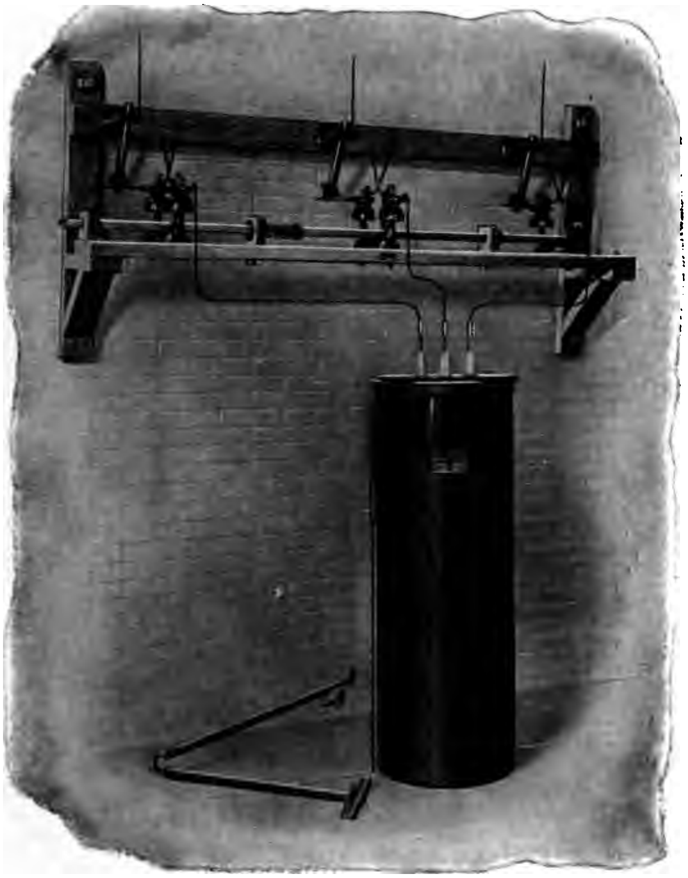

Fig. 27. Electrolytic Lightning Arrester for 7,000 Volts

Ground Detectors and Tests. Except where circuits are intentionally and permanently grounded, a leak to "ground" may be the cause of arcs at any point in the system which may be dangerous. By "ground" is to be understood the earth, walls or floors of masonry, pipes of any kind, iron beams or floors and the like. It is, therefore, required that suitable instruments and circuits be provided to indicate either continuously, or by frequent tests, whether there are such ground connections which would indicate a failure of some insulation. If such a failure is shown by the detector the trouble can usually be located and repaired before injury is done.

Ground detectors may take the form of special instruments on the switchboard or of arrangements of switches with lamps or voltmeters which can be used to test the insulation of each side of each circuit in turn. The connections should be such that the detector cannot be left out of circuit. For the various arrangements of ground detectors reference must be made to the standard electrical treatises.

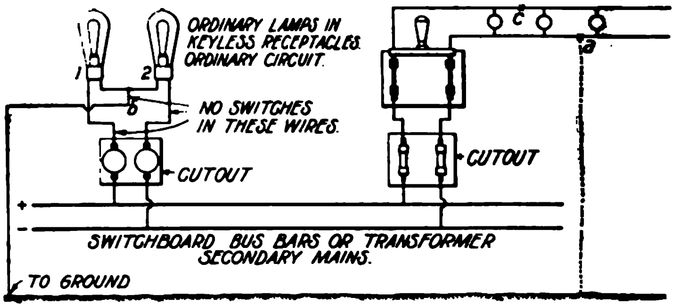
ORDINARY LAMPS IN KEYLESS RECEPTACLES ORDINARY CIRCUIT.
1
2
b
NO SWITCHES IN THESE WIRES.
CUTOUT
c
a
CUTOUT
+
-
SWITCHBOARD BUS BARS OR TRANSFORMER SECONDARY MAINS.
TO GROUND

Fig 28. Wiring Diagram for Ground Detector on Any Two-Wire Low-Voltage System

Attention may be called to the following points which are frequently neglected:

(1) Lamp receptacles should be keyless and any switches in the detector circuits should be so connected that the detector will continuously give an indication on at least one side of the circuit.

(2) The wires should always be protected by small fuses where they connect to the bus bars.

(3) If the detector is of a type depending on relative brightness of two lamps, the lamps should be very close together.

(4) Special care should be taken to secure excellent ground connection for the ground wire.

The accompanying diagram, Fig. 28, shows a very good and simple detector for any two-wire low-voltage system, and is typical of many in use. (The diagram and description are taken from a publication of the Associated Mutual Fire Insurance Companies.)

The lamp for the detector should be of the same candle power and voltage, the voltage being about the same as that of the regular lamps in the plant, and two lamps should be selected which, when connected in series, burn with equal brilliancy. Although somewhat greater sensitiveness can be obtained with low-candle-power lamps, such as 8 c. p. for example, it is believed in general to be preferable to use lamps of the same candle power as those throughout the plant, as then a burned-out or broken-detector lamp can be immediately replaced by a good lamp from the regular stock, thus avoiding the necessity of keeping on hand a few spare special lamps.

The detector lamps, being two in series across the proper voltage for one lamp, burn only dimly. If, however, a ground occurs on any circuit, as at *a*, the current from the positive bus bar through lamp No. 1 divides on reaching *b*, instead of all going through lamp No. 2, as it did when there was no ground. Part now goes down the ground wire and through the ground to *a*, as indicated by the broken line, and thence through the wires to the negative bus bar. This reduces the resistance from *b* to the negative bus bar, and, therefore, more current flows through lamp No. 1 than before, while less current flows through lamp No. 2. Lamp No. 1 consequently brightens and lamp No. 2 dims. If the ground had occurred at *c* instead of *a*, lamp No. 2 would have brightened and lamp No. 1 dimmed. This detector, while not able to indicate extremely small leaks, will show any leak that is likely to be dangerous from a fire standpoint.

Motors. Electric motors are very generally used in manufacturing plants of all sorts and their use is still rapidly increasing. They are also used very extensively for elevators, cranes, and for an infinite variety of uses in all classes of buildings. Recently portable motors of small size have come into very general use for drills, and other portable tools, vacuum cleaners, washing machines, and scores of other purposes where their cleanliness, economy, and adaptability to all service recommends them. These portable motors, however, do not in general come under the rules prescribed for stationary machines, though their use involves similar hazards and some others peculiar to themselves. These will be discussed later.

In general the same precautions should be taken with motors as with generators. Dry, clean, well-lighted locations should be chosen for them. It is a very common fault to install a motor in a space too small for it, or in a place where rubbish and dirt are allowed to accumulate. The fact that modern motors are very sturdy machines, and will continue to work even when neglected and abused, encourages carelessness in maintenance which often results in hazardous conditions. Except where unavoidable, motors must never be located in the vicinity of combustibles, in wet places, or in very dusty or dirty places. When such locations are unavoidable, an "enclosed" type of motor should be used, or a special room, Fig. 29, should be provided. Many modern types of alternating-current motors have no exposed live parts and do not have commutators or brushes and are, therefore, well suited to dusty or linty places. Fig. 30 shows a rough commutator of a motor. It is evident that as the commutator revolves, the brush which carries the main motor current will not fit well at all points and, therefore, sparking will result. In extreme cases this sparking may be dangerous, especially in dusty places or where inflammable gases are present. Where motors are used, not of enclosed types with brushes, commutators or slip rings, where sparking may occur, special enclosures should be provided. The installation of motors on ceilings, Fig. 31, or built in as parts of the special machines which they drive, often affords both the neatest

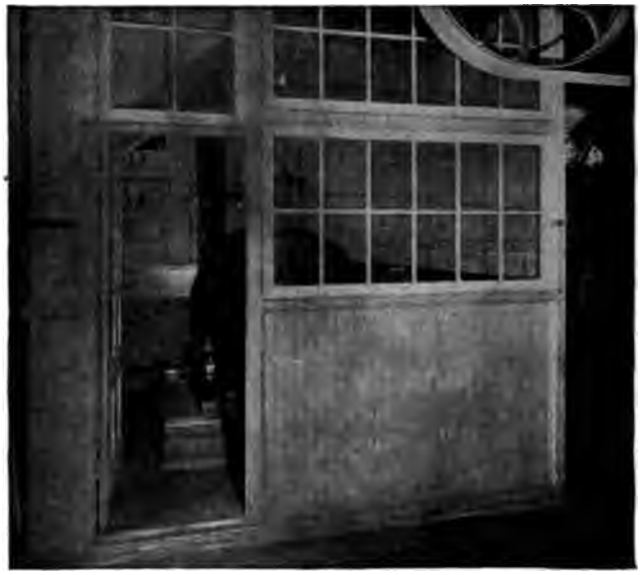

Fig. 29.* Approved Housing for Motor in Bad Location

and the safest arrangement. Motors operating at voltages over 550 volts require special precautions in respect to wiring leading to them. Motors for less than 550 volts are wired according to the general rules for low-potential systems.

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* *Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.*

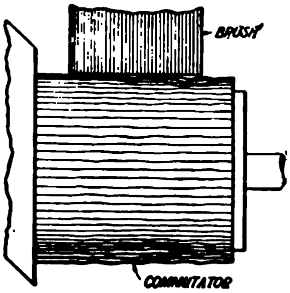

Fig. 30. Rough Motor Commutator Increases Sparking

Wiring to Motors. The supply leads to motors must be of a size to carry at least 25 per cent more current than that for which the motor is rated. This applies to all types of motors both d. c. and a. c. and is required even though the motor is not actually being used for its full load. This is called for to provide for the currents required to start the motor which are almost always greater than the current needed for continuous full load running, and also to provide a margin of safety at all times.

Wiring for Direct-Current Motors. The Code prescribes the safe carrying capacity of wires of different sizes, Page 65. Thus if a direct-current motor requires 40 amperes when working under full load, the lead wire must be of such size as to carry 50 amperes. A reference to Rule 16 shows that this will call for a No. 5 wire. As No. 5 wire is not usually made for electrical purposes it would be necessary to use a No. 4 wire.

The factors which are involved in the determination of the proper size of leads to direct-current motors are the following:

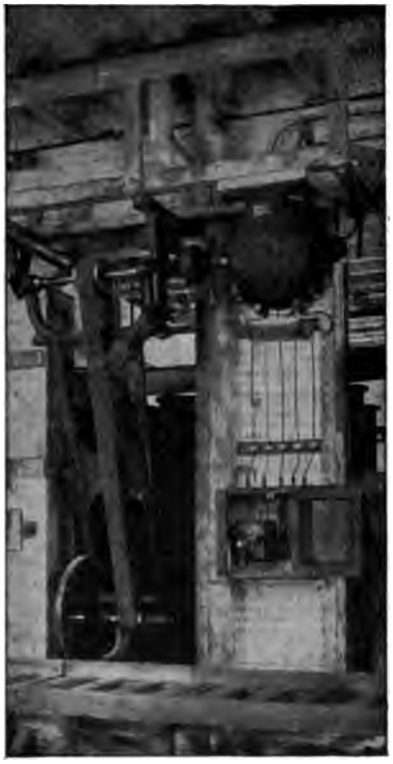

Fig. 31.* Approved Ceiling Mounting for Motor

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* *Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.*

TABLE I

Sizes of Conductors in Direct Current*

Horse-Power	110 Volts		220 Volts		500 Volts
	Concealed	Open	Concealed	Open	Open
1	14	14	14	14	14
2	10	14	14	14	14
3	8	10	12	14	14
4	6	8	10	14	14
5	6	6	10	12	14
7½	3	4	6	8	14
10	1	2	6	6	12
12½	0	1	4	5	10
15	00	0	3	4	10
17½	000	000	2	3	8
20	0000	000	1	2	8
	c. m.	c. m.			
25	250,000	250,000	0	1	6
30	350,000	250,000	00	0	5
35	400,000	300,000	000	000	4
40	500,000	350,000	0000	000	3
			c. m.	c. m.	
50	700,000	500,000	250,000	250,000	1

*The question of drop is not taken into consideration in the above table.

E = volts required by motor
k = efficiency of motor in per cent
h.p. = rated horse-power of motor

Then if I = current in amperes at full load and at the given voltage

$$I = \frac{\text{h.p.} \times 746}{E \times k}$$

When I is found, a reference to the Wire Capacity Table, Page 65, will show what size of wire is required for current 25 per cent in excess of I.

In Table I are given the sizes of conductors in Brown and Sharpe gauge required for direct-current motors of respective sizes in h.p. and voltages, on the basis of 90 per cent efficiency and 25 per cent overload on motor leads. The two columns refer to wiring run "concealed" as in conduit or "open" as on cleats.

TABLE II

Sizes of Conductors in Alternating Current*

SINGLE PHASE

H. P.	110 Volts			220 Volts		
	Amps. on Mains	Size of Wire		Amps. on Mains	Size of Wire	
		Concealed	Open		Concealed	Open
1	12	12	14	6	14	14
2	23	8	10	11	12	14
3	33	5	6	16	10	12
4	44	4	5	22	8	10
5	53	2	3	26	6	8
7½	85	0	0	42	4	5
10	110	000	000	55	2	3
	A	B		A	B	

THREE PHASE, 220 VOLTS

Horse-Power	Amperes on Mains	Size of Wire	
		Concealed	Open
1	3	14	14
2	6	14	14
3	9	12	14
4	11	12	14
5	14	10	12
7½	20	8	10
10	27	6	8
15	40	4	5
20	50	3	4
30	75	0	1
50	125	0000	000
75	185	300,000	250,000
100	250	500,000	350,000
150	370	800,000	600,000
	A	B	

---

* Size of conductor in Brown and Sharpe gauge required for alternating-current motors respective sizes in h. p. and voltages, on the basis of 90 per cent efficiency, 50 per cent erload, and 85 per cent power factor.

The question of drop is not taken into consideration in the above table.

Note. Column "A" gives currents to be used in calculating size of mains supplying more than one motor.

Column "B" gives size of wire for branches and mains supplying one otor.

Wiring for Alternating-Current Motors. The calculations for proper sizes of wires for alternating-current motors, are somewhat more complicated than for direct-current motors.

Table II gives the wire sizes prescribed by the rules of the Department of Electricity of the City of Chicago. Somewhat different values are, however, in use in other places and no universally accepted rule has yet been developed.

Switches and Protective Devices with Motors. Every motor of over ¼ horse-power must be protected by fuses or circuit breakers, and controlled by a switch; and all of these must be located within sight of the motor, and be arranged so as to open and to protect all the wires. An automatic circuit breaker which will disconnect all the wires of the circuit is considered the equivalent of both the fuses and the switch.

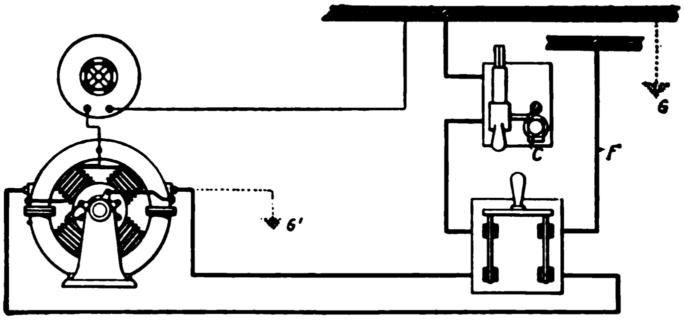


Fig. 32. Wiring Diagram of Motor Circuit Showing Inadequate Fuse Protection

The chief purpose of the fuses is to protect the motor and especially the wiring to it from overloads resulting from accidents to the motor or from the excessive current which will flow if an attempt is made to start the motor when it is for any reason unable to start and attain its proper speed. The fuses must, therefore, always be of such size as to blow with currents not in excess of the specified carrying capacity of the supply wires. Circuit breakers must not be set more than 30 per cent above the carrying capacity of the wire unless fuses are also used.

For a. c. motors, each phase (*i. e.*, each main motor circuit whether there are one or more) must have a fuse whether circuit breakers are used or not. This is because of the necessity of setting circuit breakers on such circuits so that they will not open with the large currents which flow on starting the motor. The breakers, therefore, may not protect the wires properly but the fuses act less promptly and even if of lower rating will not flow before the motor has come up to speed and the currents have been reduced to the normal amounts for actual running power. An exception to this rule is made in cases where the protective devices are on main switchboards or under constant expert supervision. Also for single-phase a. c. motors, one fuse and one circuit breaker are allowed, one in each of the two motor supply wires.

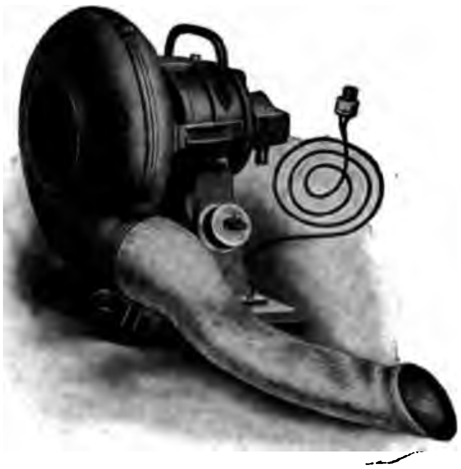


Fig. 33. Small Ventilating Outfit to be Connected to Lamp Socket

The switch at a motor is required so that the line can be readily disconnected from the motor when the latter is not in use or in case of accident. On two-wire systems, a double-pole switch is required, on three-wire, a triple-pole. If a circuit breaker is used without fuses it must be of a type which will protect the motor under all circumstances. Thus in Fig. 32 the single-coil circuit breaker does *not* comply with the rule, since, if a ground should occur on the main at G and another on the motor at G^1, the coil C of the circuit breaker would be cut out of the circuit and the breaker would fail to operate, for no provision is made to open the other line. In this case a fuse of proper size should be installed at F or a circuit breaker having a trip coil in *each side* should be substituted for the fuse and breaker shown in Fig. 32. If the circuit breaker takes the place of the switch at the motor it must be such that one line cannot be opened without opening also all the others.

Motors of ¼ h.p. or less may be connected to circuits less than 300 volts in the same way as incandescent lamps, provided the proper fuses are used in the branches supplying the power to them. Such motors, illustrated by desk-fan motors and all portable motors of small size, do not usually require starting rheostats. Fig. 33 shows a small ventilating outfit to be connected to a lamp socket.

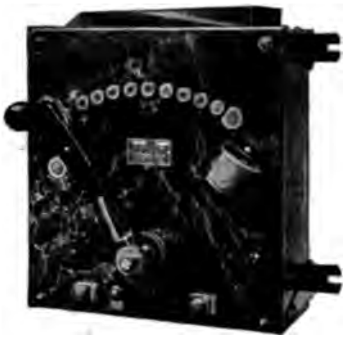


Fig. 34. Common Type of Motor Rheostat

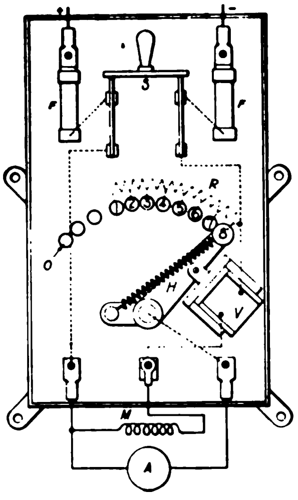


Fig. 35. Starting Rheostat Wiring Diagram

Rheostats with Motors. Rheostats are used with motors for starting them and for controlling their speed. They should always be regarded as sources of heat and installed accordingly. Fig. 34 shows a common type of motor-starting rheostat. Such rheostats (called motor starters) need to be in the circuit for only the very short time usually required to bring the motor up to speed and, therefore, they are usually so designed to carry the necessary current for only this brief period. Such motor starters, if left with current passing through their coils or grids for longer periods, will become very hot and may burn out. The manner in which a simple motor starter is connected is shown in Fig. 35 when *A* represents the armature of the motor, *M* the field coil or electromagnet of the motor and *R* the resistance coils in the starter rheostat box. The required fuses and switch are shown at *FF* and *S*. In this design the starter, fuses, and switch are all mounted on a single slate base. To start the motor, the switch *S* is first closed and the handle *H* is slowly moved from *O* to the position shown in the diagram. It will be seen that the resistance *R* during the process of starting serves to limit the current supplied to the motor armature, which would otherwise, until the motor came up to speed, be excessively large. When the handle has reached the position shown, the resistance is all cut out of the circuit. A rheostat of this sort cannot be used safely except to *start* a motor of the proper size for it. The resistances will get excessively hot if *H* is allowed to remain at any intermediate point.

Motor starters for d. c. motors must, therefore, be made so that a spring or other device will return the lever to the "off" position in case the operator attempts to leave the starter with current passing through its resistance coils. This is because these coils are not designed for this continuous duty. When, however, the lever has been moved clear across to its final position, it is held there by a small electromagnet (*V* in Fig. 35) but in this position the connections have been shifted so that the resistance coils are no longer in the circuit. If now it should happen that the supply of current should fail, the electromagnet (called the *no-voltage release*) will release the lever which will fly back to the original "off" position. Then when the supply is re-established the motor will not be injured by starting too suddenly, or by the severe arcing at the motor commutator.

Since a. c. motors usually have no commutators and are less liable to injury from sudden starting, a no-voltage release is not required in a. c. starters.

A somewhat different device called an *autostarter*, *potential starter*, or *compensator*, is often used for starting a. c. motors. It is a form of transformer which allows only a portion of the line voltages to be applied to the motor until it is well started. Autostarters are to be regarded as sources of heat, and much the same precautions are necessary as with ordinary starters containing wire coils or iron grids. If they contain oil-immersed switches or coils, the oil adds a further hazard on becoming overheated or spattered about. Fig. 36 shows the interior of a compensator.

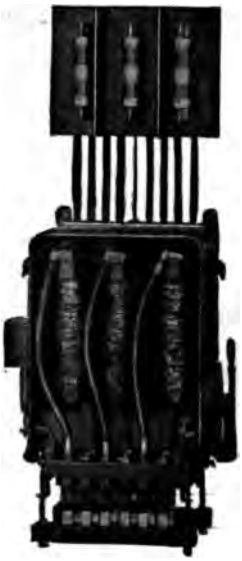


Fig. 36. Interior View of Compensator

In general, motor starters, either d. c. or a. c., involve both the hazards of switches and those of possibly overheated coils of wire or other parts, and must be treated accordingly.

Another class of rheostats includes those which are intended for regulating the speed of motors and generators. They are necessarily used continuously whenever the machine is running and, therefore, must be proportioned so that their coils or other resistances will not become overheated, even when the necessary current traverses them for hours at a time. Fig. 37 shows a large rheostat of this type. Among these rheostats are classed field rheostats for dynamos, controllers for motors (as distinguished from motor starters), theater lamp dimmers, and, in fact, *all* rheostats or resistances which are required to be continually in the circuit. Some motor starters are designed to serve also as controllers and may have two sets of resistances, one for starting only and the other for continuous duty in varying the speed of the motor. These are especially useful in connection with machine tools and similar apparatus.

Special forms of rheostats having their resistances so enclosed that a burn-out will not cause sparks, are required in dusty or linty places, such as flour mills, various textile mills, etc. If such specially protected starters are not supplied, the starting apparatus should be in special rooms where the dust or lint can be kept out.

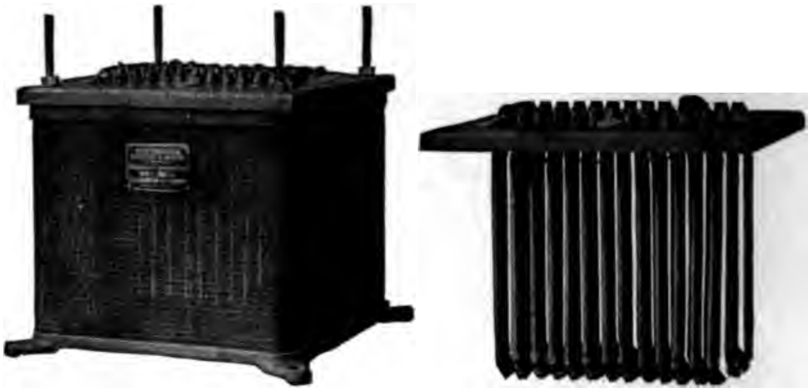


Fig. 37 Closed and Open Views of Large Rheostat for Continuous Service

The dangers to be guarded against in all rheostats of every type arise from the fact that these appliances must from their very nature be sources of heat. By liberal design and good ventilation the *temperatures* can be kept low; but all rheostats should be installed with the idea that they may become overheated by failure or misuse, Fig. 38. The large amount of insulated wire often used, and the oil in which parts are sometimes immersed, may furnish a considerable amount of fuel, and in severe burn-outs, flames may result and molten metal be ejected. A large amount of smoke usually accompanies a burn-out of a rheostat.

Storage Batteries. Batteries of large size are now in common use. These are practically always storage batteries, that is, batteries which are recharged by having current from a generator supplied to them from time to time. What are called primary batteries, that is cells in which there is a chemical action which sets up a current without any machine being used to charge and recharge

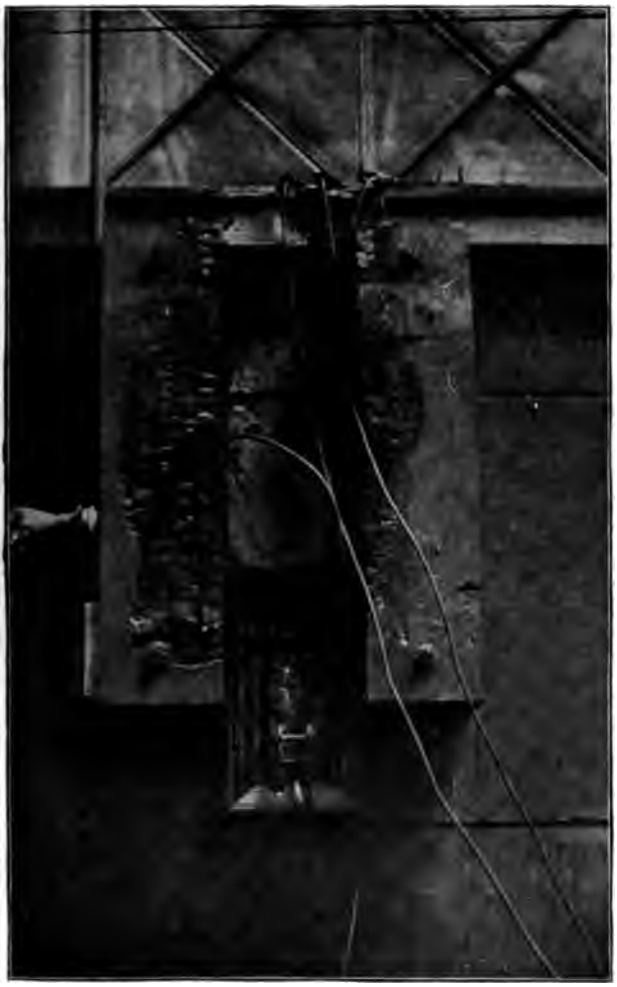


Fig. 38. Example of Badly Installed Rheostat and Switch

them, are sometimes of large size, and develop fairly high voltages. They are, however, used chiefly for telegraphs and other signaling work and need not often come under the supervision of underwriters or fire-protection engineers.

Storage cells, however, where they are capable of developing the same voltage (100 to 600 volts not uncommon) require the same general precautions as dynamos or motors since they produce like amounts of energy. Furthermore, it is a property of such batteries that in case of a short-circuit they can for a short time supply very large currents, far larger than they are normally called upon to supply. Thus they may be termed reservoirs of energy, capable of producing trouble if their output is not properly controlled.

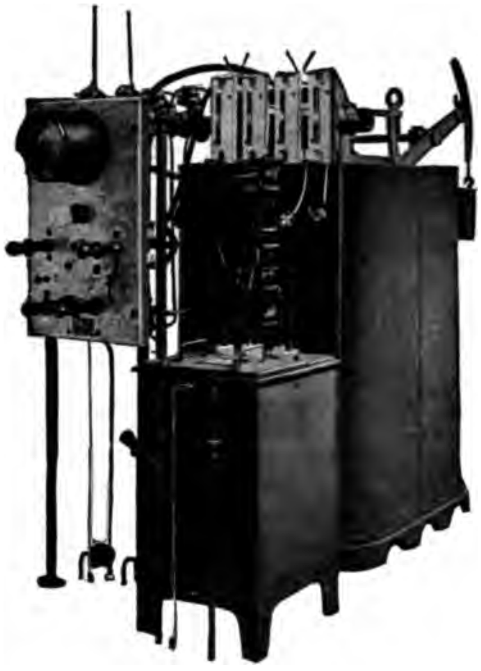


Fig. 39. General Electric Arc Lighting Transformer with Series Rectifier

Storage battery rooms should be thoroughly ventilated. The action of the current in charging the battery, liberates at times large quantities of hydrogen and oxygen, and if these should accumulate in the right proportions, they would form an explosive mixture which might be exploded by any accidental spark.

The water and acid used about storage batteries make it necessary to provide especially good insulation. The battery jars are best mounted on glass strips set on special porcelain insulators. The usual precautions for rooms where acid fumes exist should be taken in battery room wiring, and metal parts must not be such as to be affected by corrosion, since a decrease of the cross-section area of any current-carrying part may ultimately reduce the metal to a degree that will cause overheating or, in case of an actual break, a dangerous arc.

Transformers. In central or substations or in large power rooms of isolated plants or factories, the chief point in the installation of transformers is the provision for preventing injury, the smoke resulting from burning out of the coils or, in the case of oil-filled cases, from the boiling over of the oil. These effects are, of course, produced only from some accident to the apparatus or circuits, but transformer fires are peculiarly difficult to fight, and the oil and the insulations on the windings produce, at high temperature, large volumes of smoke which may damage goods in other parts of the building than the transformer room itself, or which might be mistaken for a fire and result in water being thrown into the building entailing a heavy "water loss." Transformers should always be located in clean, dry places with ample space about them. Fig. 39 shows a General Electric constant-current arc-lighting transformer with series rectifier outfit for 4-ampere 50-light system.

OUTSIDE WORK

Defects or failure of electric light or power circuits outside of buildings, as on poles or over the roofs or walls of buildings, may become the cause of fire by setting up abnormal conditions in appliances connected to them, by setting fire, either by overheating or arcing, to buildings on which they are supported, or especially by *crosses*. By a *cross* is meant an accidental touching by wires of one circuit or line with those of another line. By such accidental contacts lines may become charged with a higher voltage than they or their appliances are suited for. Thus a cross between a 2,200-volt arc-light wire and a 110-volt house-lighting circuit may cause current from the 2,200-volt circuit to pass into one or more houses where it will perhaps blow fuses with an explosive action, or cause very dangerous arcs as it passes to the ground through some defective insulation, Fig. 40. Similarly it is very dangerous for an ordinary lighting circuit to become crossed with a telephone wire, since the insulation and carrying capacity of telephone wiring is not such as to resist the effects which might be produced. For reasons such as these, outside wiring has a definite relation to fire hazard even in buildings.

Wiring. In very many cities and towns insufficient attention was paid to outside wiring until the streets and alleys became crowded with circuits of all sorts, each put up as was cheapest or most convenient at the time it was constructed. Where some of these circuits are of high power and high voltage exceedingly dangerous conditions exist, and the hazard may be extended over large areas remote from the place where actual failure occurs, since the resulting accidental currents may pass over any of the lines involved to buildings at considerable distances. The efforts of fire-protection engineers and insurance interests should be directed toward the correction of faulty outside wiring conditions, which if neglected are bound to

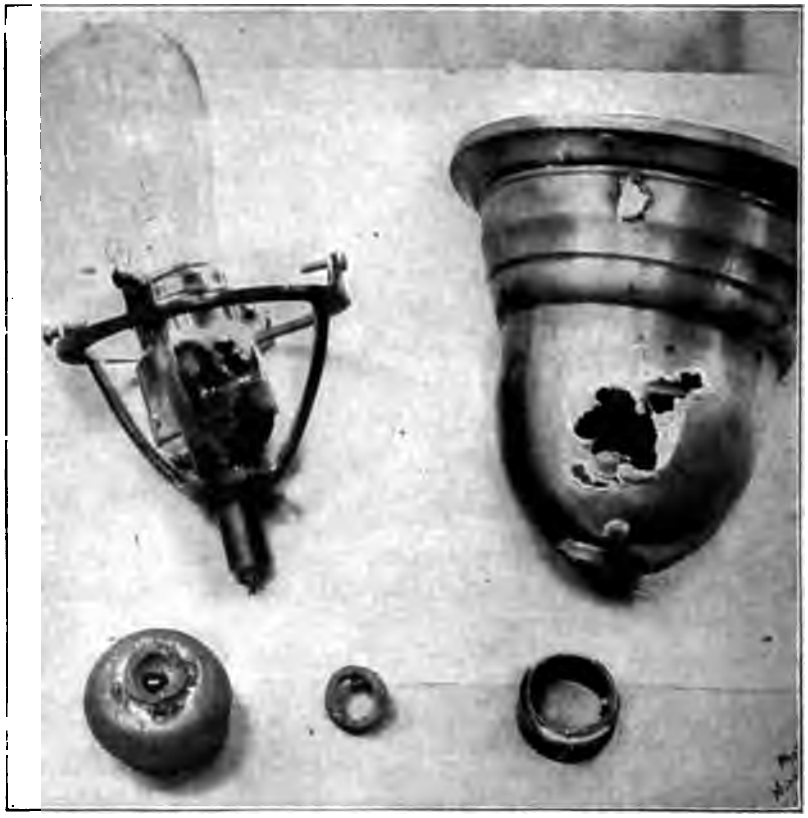


Fig. 40. Result of Cross Between 2,200-Volt Lighting Circuit and 110-Volt House Circuit

become progressively worse and constitute a serious menace to lives and property.

Where an insured property is clearly jeopardized by outdoor wiring, excellent electrical conditions indoors can at best afford only a partial safeguard, and fire-protection engineering should apply itself to remove the defects out-of-doors as well as in.

Underground System. The placing of electric wires underground, especially where low voltage and signal circuits are carried in separate conduit systems, affords the most thorough solution of the hazards of town and city wiring. Underground wires are, of course, less liable to accidents of weather and storm, and are, therefore, preferred by operating companies although the expense of putting wires underground often prevents or postpones a change. Legislation prescribing a gradual change, a certain amount of wiring being put underground each year, has often produced results without undue hardship to electric companies. However, there are certain well defined precautions and standard methods for outside work which can reduce hazards to a great extent.

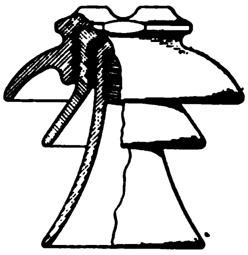


Fig. 41. Petticoat Insulator

Standard Practice. Line wires should have either rubber insulating or weatherproof covering. The latter consists of three tight cotton braids, each thoroughly impregnated with a waterproof compound. All tie wires, as at insulators, must have an insulation equal to that of the wires they confine. The insulation of outside wires on poles is required as an additional protection, but is not in any way depended on for insulation at the supports. The use of bare wires would greatly increase the probability of crosses in cases of breakage of wires.

Standard practice is to use glass or porcelain insulators at least 1 foot apart on pole cross-arms and to ground all metallic sheaths of cables. Fig. 41 shows a cross-section of one form of porcelain insulator. The "petticoats" will nearly always have a dry space underneath their lower edges, and even if not dry, the length of the path offered to the current escaping over the wet surface is so great that the leakage is small.

All joint wires should be soldered and carefully insulated. The joint should be made mechanically and electrically secure before the solder is applied. Good joints are requisite to lessen the chance of wires falling as well as to prevent arcs on the wires themselves.

Proximity of Wires to Electric Light and Power Lines. Probably the most common and also the most dangerous fault in outside work is the running of telephone and other signal wires too close to electric light and power lines. Wires of this sort should never be on the same cross-arms and it is much the best practice wherever possible to keep telephone wires on poles on one side of a street, and light and power wires on the other, giving special attention to the necessary crossings, if any. In all outside pole work in towns due regard should be given to the fact that lines consisting of many wires are a serious hindrance to firemen in attacking a fire in the adjacent

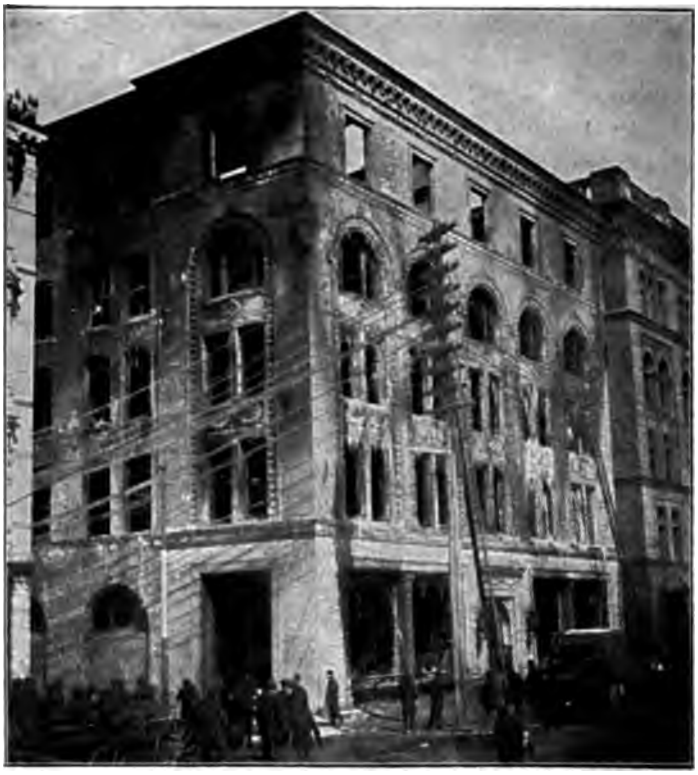


Fig. 42. Presence of Overhead Wires Hinders Firemen

ildings, Fig. 42. The disposition of the lines should be such as reduce this as far as practicable; but placing wires underground is e only complete solution of this problem.

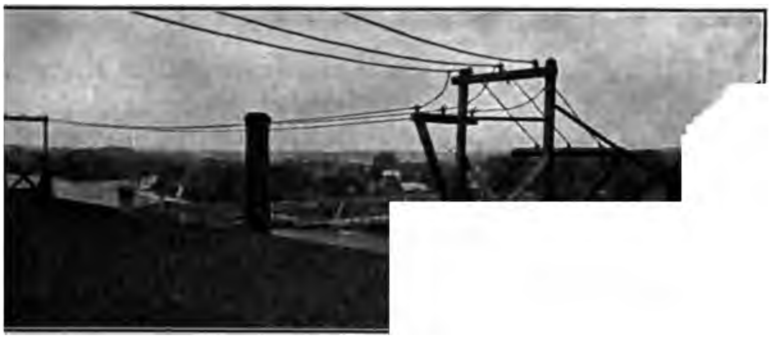


Fig. 43.* Well-Installed Roof Wiring

Outside Wires on Buildings. Where outside lines are supported buildings, they should be at least 7 feet above the highest point flat roofs and at least 1 foot above the ridge of pitch roofs over

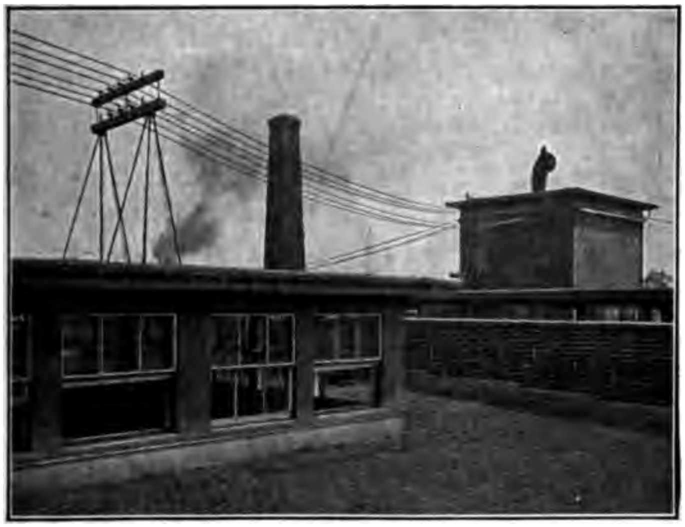


Fig. 44.* Approved Form of Roof Structure for Safe Installation

ich they pass and the roof structures should be of the most sub-
ntial description. Figs. 43 and 44 show two forms of roof struc-
re which hold the wires high enough so that they cannot sag and

urtesy *Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.*

touch the roof and so that they are not liable to be touched or disturbed by persons walking on the roofs. Where outside wires are brought from pole lines into buildings special precaution must be taken. Such wires are spoken of as service wires or services.

The portion of such wires from the service switch in the building and the first outside support must be rubber insulated. Every precaution must be taken to keep service wires free from contact with cornices, awning-frames, shutters and the like, under all conditions.

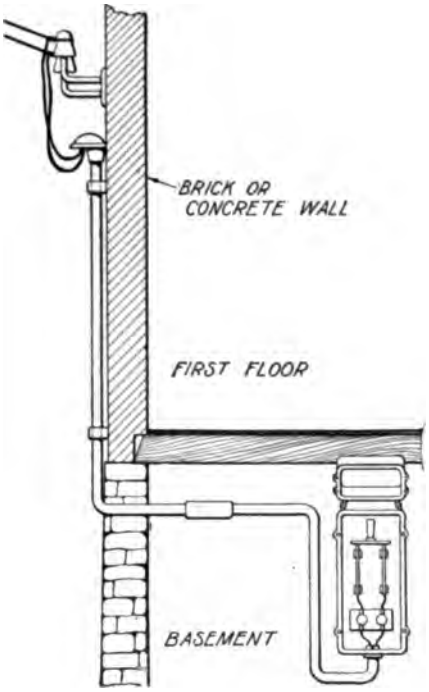


Fig. 45. Section of Approved Conduit Wiring Showing Provision Against Moisture

Usually, for low-voltage circuits, it is best to put the wires in metal conduit, as shown in Fig. 45. This drawing also shows the drip loops which should always be provided, the insulators on brackets secured to the wall and the special *pipe-cap* on the top of the conduit to keep rain out of the pipe. Where conduit is not used, porcelain bushings may be used, slanting upward through the wall toward the inside.

In general it is better to have service wires enter through the basement rather than through an upper story or attic. Where wires are carried along side walls outside of buildings, they should be supported on glass or porcelain insulators, not more than 15 feet apart. Where not exposed to weather, porcelain knobs may be used if not more than 4½ feet apart.

Trolley Wires. Trolley wires must be of ample size for mechanical strength (No. 0 B. & S. gauge copper or No. 4 B. & S. gauge silicon bronze). Protection against crosses must be ample and street railway trolleys and feeder cables must be capable of being disconnected at the power station or of being divided into sections so that in case of fire on the railway route, the current may be cut off from the particular section and not interfere with the work of the firemen.

Electrolysis. Whenever an electric current passes between a pipe or wire underground into damp earth an electro-chemical effect is produced which may, under certain conditions, produce a disintegrating effect on the metal pipe or wire and eventually destroy it. Whenever an electric current passes through a conducting liquid which is not a chemical element, the liquid is decomposed. The salts and acids in the liquid are thus decomposed and metal plates by which the current is led into and out of the liquid are also affected. This process is called *electrolysis,* that is, breaking up of chemical composites by electric currents.

It is at once evident that water and gas pipes of iron buried in moist earth provide the necessary combination for electrolytic effects and that pipes in areas traversed by currents through the earth may be injured by such chemical disintegration. In cities and towns where there are large electric currents which use the earth as a "return path," these effects, if improper conditions are allowed to exist, may become very serious and have a bearing on the fire hazard chiefly as they may jeopardize the water mains and supply pipes to an extent sufficient to render the fire-fighting facilities unreliable in emergencies. Since the direction of alternating currents reverses many times each second, the chemical effects which they can produce are also reversed and, therefore, in general alternating currents in the earth are not liable to produce dangerous electrolysis. There are, however, direct currents which usually employ ground returns and by far the commonest are the currents of the usual overhead trolley street railways. It is to these, therefore, that the following explanation applies. Fig. 46 illustrates the way in which the current in a trolley circuit returns to the generator. Such circuits in this country

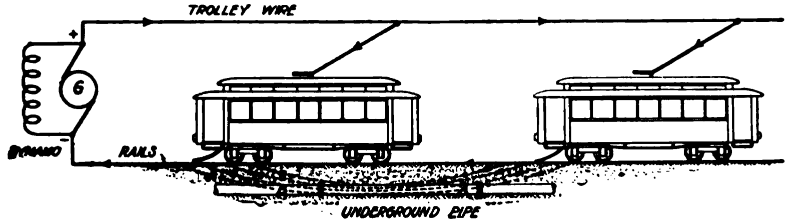


Fig. 46. Diagram of Electrolytic Effects of Street Railway Return Currents

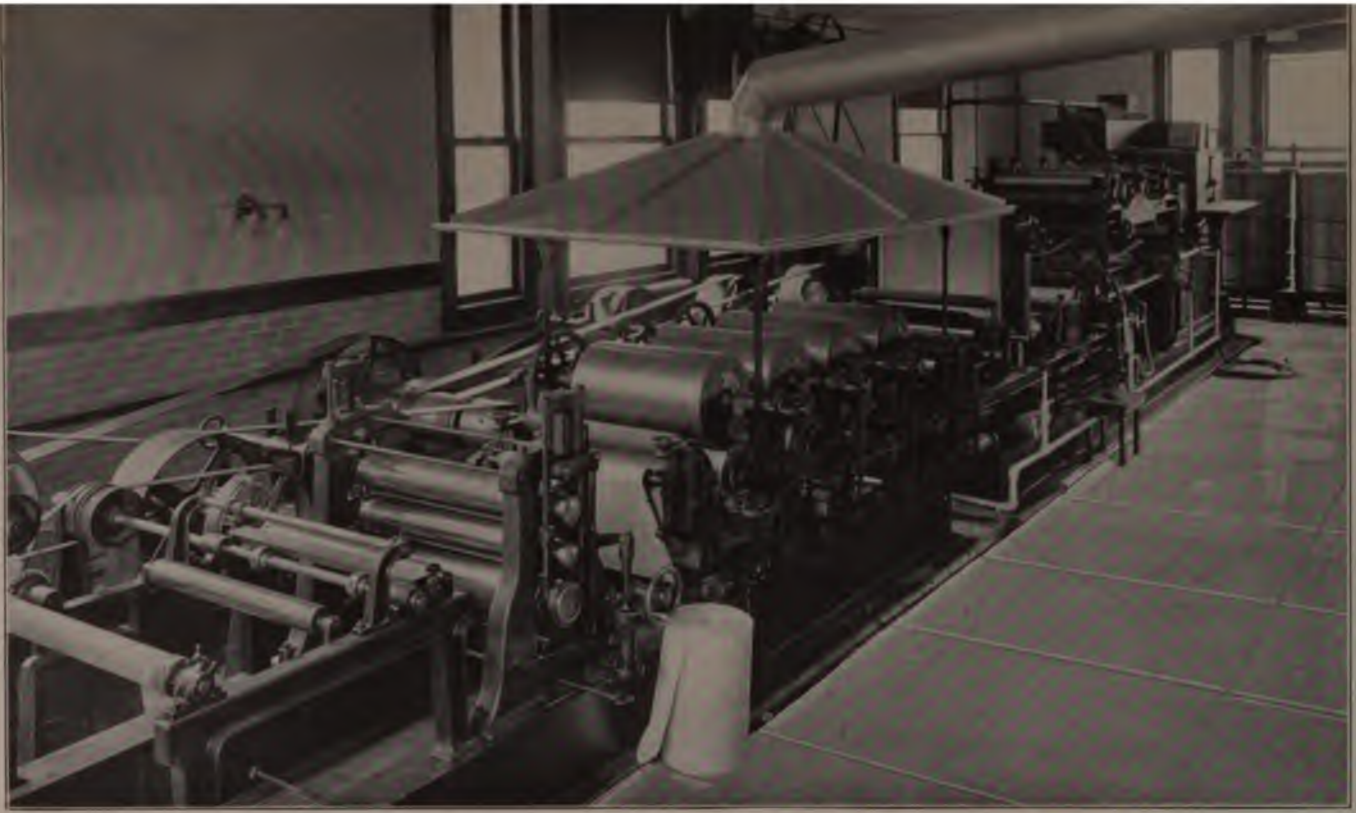
are almost invariably direct current at 500 to 650 volts and the *positive* side of the dynamo is regularly connected to the overhead wire. The current thus passes out over the trolley, through such cars as are in operation and back to the negative side of the dynamo, by the rails, or through pipes, moist earth or other conducting substances underground. The negative side of the generator is, of course, connected to the rails and ground. The return current divides according to the conductivity of the different paths afforded it and the actual distribution of currents in the earth may be very complicated and is subject to great variations from point to point. Careful "electrolytic surveys" are necessary in order to discover fully the actual current arrangements existing underground in any town or city.

In general, however, it is important to notice that wherever the current *leaves* a pipe for the earth, as at *B* in Fig. 46, the iron of the pipe is carried away into the earth, just as in a silver plating battery, silver is carried away from the silver plate toward the article which is being plated. It is this action which is meant by electrolysis as the term is usually employed with reference to underground pipes and earth currents and the result, as has been stated, may be a destruction of the pipe at one or at many points.

For the diminution of such electrolytic corrosion every means should be taken to afford a low-resistance path for the return circuit. This is also of advantage from the viewpoint of economical operation since it takes power to drive the current through a high-resistance return path. Large copper conductors are often laid between the rails and parallel to them, frequent heavy cross wires being used to connect this copper cable to the rails. Good bonds between rails either of low-resistance tie plates, or still better of electric welds between rail ends, are of great value.

The general arrangement and size of return wires and rail should be such that the difference of potential in volts between the grounded terminal of the generator and any point on the return circuit will not be more than 25 volts.

Where pipes or other underground metal work are found to be electrically positive to the rails or surrounding earth, that is, so that current tends to flow *from the pipes to the rails or earth*, special conductors should be provided to connect the pipes to the rails to



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carry such currents and thus prevent, as far as possible, the effects of electrolysis. Very elaborate investigations of electrolysis as affecting water mains, gas pipes and other underground metal have been made in many cities and the co-operation of city authorities, water companies, and electric power and railway companies, has in many places resulted in greatly lessening, if not in entirely removing, the dangers from this cause. Surveys should be repeated occasionally since new electric circuits or new pipe lines may create an altered condition in underground distribution of currents.

High Tension Lines. In recent years there has, in most parts of the country, been a very great increase in the number of high-tension power-transmission lines and the voltages have also become much higher. Overhead lines of this class present certain problems requiring very careful attention. The Code states the following causes of fire which may come from high-voltage (over 5,000) lines:

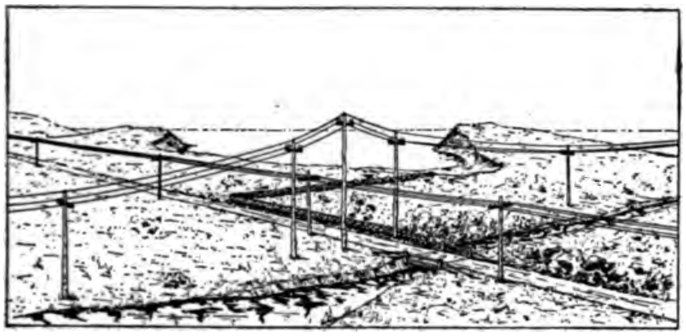

Fig. 47.* Crossover Arrangement for High-Tension Circuits

> Accidental crosses between such lines and low-potential lines may allow the high-voltage current to enter buildings over a large section of adjoining country. Moreover, such high-voltage lines, if carried close to buildings, hamper the work of firemen in case of fire in the building. The object of the rules is so to direct this class of construction that no increase in fire hazard will result, while at the same time care has been taken to avoid restrictions which would unreasonably impede progress in electrical development.
>
> It is fully understood that it is impossible to frame rules which will cover all conceivable cases that may arise in construction work of such an extended and varied nature, and it is advised that the Inspection Department having jurisdiction be freely consulted as to any modification of the rules in particular cases.

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*Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

The very best way to guard against accidental crosses between high-tension lines and other circuits is to have them follow different routes. This can often be accomplished by mutual agreement of the parties interested even when a change in one of the routes will be necessitated.

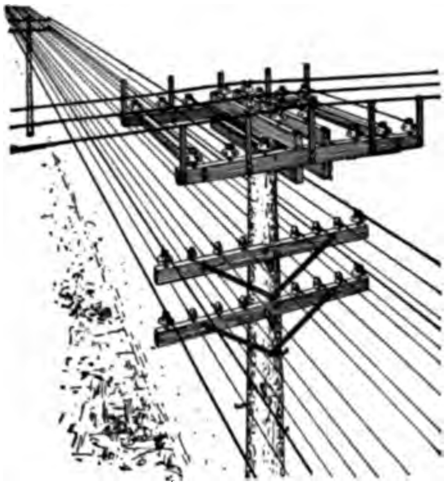

Fig. 48.* Joint-Pole Crossing with Mechanical Guards

High-tension lines should not approach other pole lines nearer than a distance equal to the height of the taller pole and such lines should not be on the same poles with any other lines except such signal lines as may be used by the company operating the high-tension system.

Where such lines must necessarily be carried nearer to other pole lines than is specified above, or where they must necessarily be carried on the same poles with other wires, extra precautions to reduce the liability of a breakdown to a minimum must be taken, such as the use of wires of ample mechanical strength, widely spaced cross-arms, short spans, double or extra heavy cross-arms, extra heavy pins, insulators, and poles thoroughly supported. If carried on the same poles with other wires, the high-pressure wires should be carried at least 3 feet above the other wires, but this arrangement should never be adopted unless it is impossible to do otherwise. Where such lines *cross* other lines, the poles of both lines must be of heavy and substantial construction.

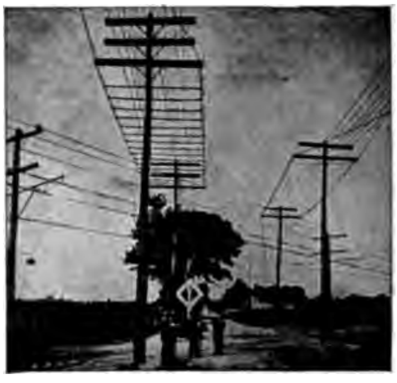

Fig. 49.* Use of Screen on High-Tension Crossover

The Code contains quite detailed specifications for the safe construction of crossovers and other details of high voltage lines which should be carefully studied and followed.

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* *Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.*

Fig. 47 shows one arrangement for a crossover. A *joint-pole crossing* may sometimes be used and Fig. 48 shows such a crossing with mechanical guards and wires on the upper or high-tension line cross-arms. Sometimes a screen either supported on high-tension insulators or grounded may be suspended between the lines at the crossover as illustrated in Fig. 49. When necessary to carry high-tension lines near buildings they should be at such height and distance from the building as not to interfere with firemen in event of a fire. Such interference might arise either from the difficulty of placing ladders or from the danger of shocks to firemen holding hose nozzles, streams from which might strike the high-tension lines.

Mounting of Transformers. Oil-cooled transformers should not, in general, be installed in buildings, and an outside location is always preferable; *first*, because it keeps the high-voltage primary wires entirely out of the building; and *second*, because of the possible injury from smoke and oil in case the transformer burns out or is overloaded. Figs. 50, 51, and 52 show transformers installed on a pole, on the outside wall of a mill and in a special fireproof vault, respectively.

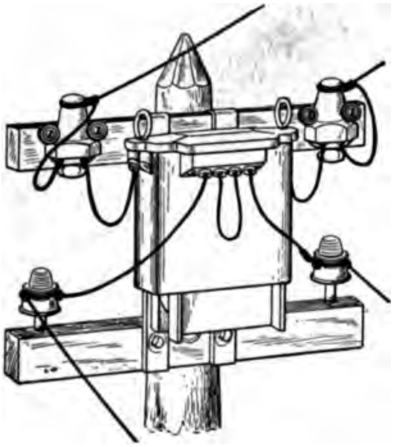

Fig. 50. Approved Pole Installation of Transformer

Grounding of Circuits. One of two courses should always be followed with regard to any electrical connection between circuits or apparatus and the earth; either arrange to have no such connection at all, and secure good insulation between live parts of circuits and the earth, or provide a good earth connection of sufficient capacity well installed to care for any current liable to pass to earth, either regularly or in case of accident.

In general it should be remembered, that if an entire electric circuit including the generator, lines, and all connected apparatus and devices are thoroughly well insulated from the ground, *one* accidental ground will produce no effect since there is no return path from the ground to another point on the system. However, we cannot be sure that an installation will be kept free from grounds even if originally so installed, since wear, deterioration of insulating materials, breaking of parts of devices, or the effects of dirt and damp may bring on a "ground" which will not be discovered until a second ground connection is established which permits current to flow with consequent heating and arcing. Under such conditions, the fault is liable to become rapidly worse. Not the least important thing about such failures of electrical circuits, is the danger of injury to persons who may become a part of the ground circuit. Thus a mechanic working on a line shaft in a mill, by touching simultaneously a live part of the circuit or a poorly insulated live wire and the shafting, may make his body part of a path for the current to ground. While 110 volts or 220 volts either a. c. or d. c. are rarely enough to kill a person, painful accidents may be caused directly or indirectly by shock, and voltages of 440, 500, or higher may readily be the cause of death if the conditions are such as to permit any but very small currents to pass through the body. While, of course, liability of injury to persons is not a "fire hazard," still good construction should provide (both in original installation and in upkeep) all reasonable protection, to persons and property.

Fig. 51.[*] Approved Transformer Installation on Outside of Building

In direct-current three-wire systems of electrical distribution, the middle or neutral wire is regularly grounded at the central station. In systems where the cables are underground, the neutral must also be grounded at each distributing box, through the box; and in overhead systems the neutral should be grounded every 500 feet. The neutral in such systems is supposed, normally, to carry either no current, or such small amount of current as may result from a different amount of power being temporarily taken from the two outside wires. If in any system the neutral is grounded at all, it should be done thoroughly so as to prevent the current escaping to ground where the connections may be so poor as to cause unsafe heating.

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[*] *Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.*

Two-wire direct-current systems are not to be grounded at all. Suppose in Fig. 53 some current-carrying part of the dynamo *D* is grounded, that is, in electrical connection with the earth, as through the bolt and the damp wood base of the machine. If this be all, no current will flow so long as there is no other ground connection to any other part of the circuit. But suppose that somewhere in the building a wire touches a gas pipe as at *B* and the insulation on the wire at *B* is worn by vibration or is defective for any reason. The gas pipe is, of course, connected to the earth and the current then has a path through the pipe, earth, bolt, base, and frame of the machine. The whole voltage of the dynamo may, therefore, drive current through this path, causing an arc to form at *B* between the wire and the pipe which will burn a hole in the pipe and set fire to the escaping gas. Evidently the greatest pains should be taken to prevent wires from coming in contact with grounded piping or other metal.

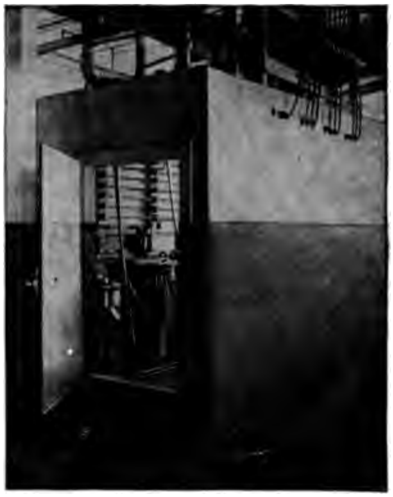
Fig. 52.* Transformer Installation in Fireproof Vault

Alternating-current systems almost invariably include transformers in which the higher line voltage is "stepped down" to the voltage required for lamps and motors. Common line voltages are 1,100, 2,200, and 3,300 volts, while the secondary voltages may be 100, 110, 220, 440 or 550. With such systems as are commonly used for distributing light and power, it is preferable to ground the sec-

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Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

ondary or low-voltage side. The ground connection may be made either at the transformers or at individual service entrances. At transformers the connection is made at the neutral or middle point of the secondary winding or coil. With three-wire a. c. distributing systems the neutral wire itself is grounded. Sometimes, when a neutral point is not accessible, *one side* of the secondary circuit may be grounded, provided it will not establish, between the ungrounded side and the earth, a difference of potential of over 250 volts. A greater potential difference than this would cause all insulators on the system to be subjected to undue strain and perhaps cause trouble.

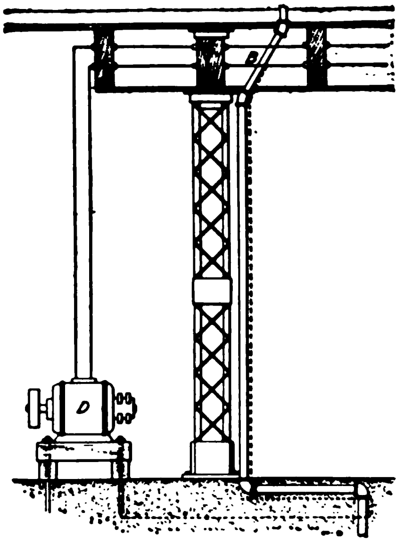

Fig. 53. Faulty Installation of Two-Wire Direct-Current Dynamo

It should be remembered that a poorly made earth connection may be worse than none. The rules, therefore, prescribe in detail how to secure *good* connections. The wire should be of large size and should be run in as nearly a straight line as possible, avoiding kinks, coils, and sharp bends which are objectionable since they impede the flow of alternating-current or lightning discharge.

Individual transformers and building services may be grounded to water pipes by carrying the ground wire into the basement and connecting it to the *street* side of meters, main cocks, etc., so that any resistance which these might offer in the ground path might be avoided.

The underwriters' rules give the following directions for making ground connections:

> In connecting a ground wire to a piping system, the wire should be sweat into a lug attached to an approved clamp, and the clamp firmly bolted to the water pipe after all rust and scale have been removed; or be soldered into a brass plug and the plug forcibly screwed into a pipe-fitting, or where the pipes are cast iron, into a hole tapped into the pipe itself. For large stations, where connecting to underground pipes with bell and spigot joints, it is well to connect to several lengths, as the pipe joints may be of rather high resistance.

Where ground plates are used a No. 16 Stubbs' gauge copper plate, about 3 × 6 feet in size, with about 2 feet of crushed coke or charcoal, of pea size, both under and over it, would make a ground of sufficient capacity for a moderate-sized station, and would probably answer for the ordinary substation or bank of transformers. For a large central station, a plate with considerably more area might be necessary, depending upon the other underground connections available. The ground wire should be riveted to the plate in a number of places, and soldered for its whole length. Perhaps even better than a copper plate is a cast-iron plate with projecting forks, the idea of the fork being to distribute the connection to the ground over a fairly broad area, and to give a large surface contact. The ground wire can probably best be connected to such a cast-iron plate by soldering it into brass plugs screwed into holes tapped in the plate. In all cases, the joint between the plate and the ground wire should be thoroughly protected against corrosion by painting it with waterproof paint or some equivalent.

In the past few years, there has been much discussion of this question of grounding, but the general tendency is no doubt more and more in favor of grounding all circuits where so doing will protect life and will not introduce extremely hazardous conditions as regards fire. The following statement of arguments for and against grounding is taken from the explanatory notes of the Associated Factory Mutual Fire Insurance Companies:

If the primary and secondary coils of a transformer come into contact electrically, the high-voltage primary current may flow to the secondary system. If this should happen, the life of any one handling any part of the secondary system would be endangered, and fires would probably be started by arcs caused by breaking down of the insulation of the wires or fittings on the secondary system. If, however, the secondary coil is grounded, a breakdown in the transformer cannot cause a dangerous difference of potential between the secondary system and the ground, and only with certain unusual combinations of contacts between the primary and secondary wires outside of the transformers will this protection fail to prevent the voltage of the secondary system from being raised above its normal limit. In order to secure the full benefit of the ground connection, reliable primary fuses of proper carrying capacity must be provided.

The *middle* of the secondary coil is the proper point to ground, as there is then only half the normal secondary voltage between either side and the ground, thus reducing the liability of a breakdown of insulation and also materially lessening the danger of fire if a breakdown does occur.

There is an objection to grounding the secondary on the other hand, for when this is done, the first breakdown of insulation may mean a short-circuit and a possible fire. With a system free from grounds, a breakdown must exist on each side of the system to cause a short-circuit, and with proper ground detectors the first can generally be discovered and remedied before the second occurs.

Grounding is, therefore, a choice of evils, but in many cases it is believed to be a lesser one than to risk getting the primary current on the secondary system. This is especially true where the primary voltage is high, say 3,500 or over. For this reason it is advised that all transformers be so designed and connected that the middle point of the secondary coil can be reached if, at any future time, it should be desired to ground it.

After the transformer secondary has been properly grounded a test should be made, especially if the transformer is some distance from the building supplied, in order to determine if the protection expected from the ground connection at the transformer is really effective inside the building in question, and if not the connection should be extended to accomplish the desired result. Cases have been known where the effectiveness of a ground connection has been limited to a comparatively small area, due to the exact conditions of the earth in the neighborhood of the ground plate and between it and the point where the protection due to the grounding was desired. The entire ground connection should be carefully examined at least once a year.

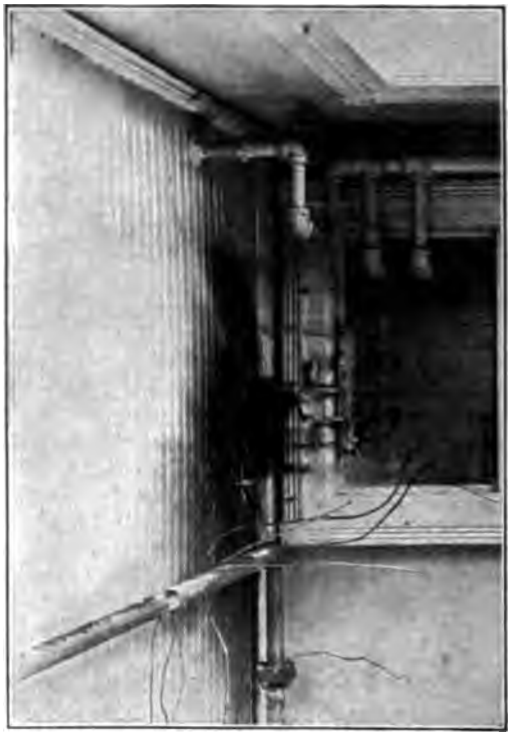

Fig. 54. Effect of Short-Circuit from Lighting Wires to Bell Circuit

INSIDE WORK

Under this heading are included the rules for wiring and appliances for light, heat, and power distribution and use. These cover the most general cases of electrical installations as they relate to fire prevention and protection in buildings of all classes. The installation of wires and apparatus for signaling systems, such as electric bells (battery current bells), telegraphs, telephones, fire alarms, and the like, is not covered in the general rules for "Inside Work" since they usually present no hazard in themselves but only as they may become dangerous because of their liability to become crossed with light, heat, or power wires either outside or inside of buildings, Fig. 54.

WIRING SYSTEMS

The present approved methods of electrical work inside buildings in this country have been developed through many years of experience, beginning with the first applications of electricity for lighting buildings and gradually changing as the possible dangers became more generally recognized, and as improved means of guarding against them were devised. In this development the efforts of insurance and municipal authorities have been supplemented by an immense activity on the part of inventors and manufacturers in supplying new devices and materials. The net result has been on the one hand an elaboration of rules and an approach to a few standard systems of construction and on the other hand the production of an almost endless variety of materials available for electrical purposes. Methods and materials which at first seemed adequate have become obsolete after a few years' use. At present, however, few important changes appear to be in progress but in many minor details the development is still going on.

At first, electric wires were laid as seemed most convenient in floors, partitions, and over walls and ceilings, either in channels cut for them, in wood casings, or supported on wood cleats with almost no regard to protecting the wires from injury, or the adjacent combustible materials from being ignited by overheated wires or by arcs. Today, however, these earlier crude methods are wholly abandoned and it is generally conceded that the best protection against electrical fires lies in the adoption of the most approved methods even when the first cost of an installation is increased to some extent. Fig. 55 shows some defective wire joints as found in actual use.

In buildings of the better class, the electric installation is carefully considered in the plans, and provision is made for its safety as well as for its efficiency and economy. However, in cheaper buildings, and very often in small stores, apartments, and residences, the electrical work is left to be arranged as best it may and to be installed by careless workmen without expert supervision. In electrical matters as in most other affairs, cheap work is generally poor work, and deviation from the methods shown by experience to be reliable are usually prompted by a desire to save money at the expense of safety and permanence.

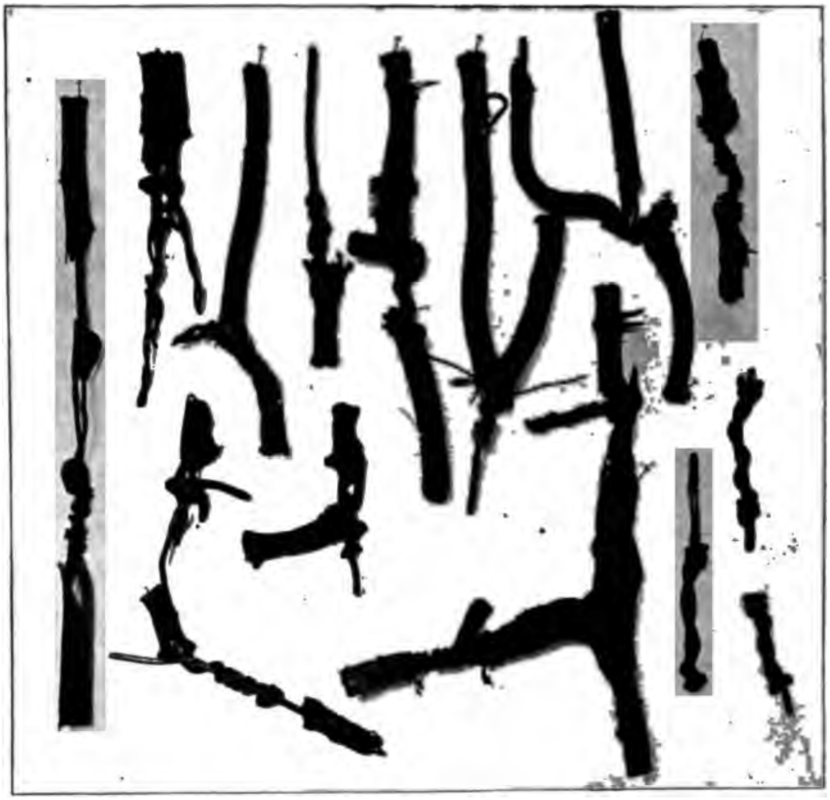

Fig. 55. Typical Defective Joints in Electric Installation

The method of bringing supply or "service" wires into buildings naturally demands first attention. Where street mains are underground the lines should, wherever possible, enter through the basement or cellar walls, the lead-covered cables being carried through the foundations through tubes tightly sealed.

Where mains are overhead, the supply wires may enter either through the basement, being carried down the outside of the wall in iron conduit, or through some upper portion of the wall, though the former entrance is almost always preferable. Where transformers are used they may be on poles near the building or mounted on the outside wall in a substantial manner. An entrance through a roof, near a cornice or into little used or inaccessible attics or lofts, should be avoided. Where wires or cables pass through the outside walls there must be either iron conduit or insulating bushings sloping upward toward the inside, and the wires outside must have drip loops which will prevent moisture following along them into the wall. The fastenings of the wires to the building must be most substantial and good insulators must be provided for the supply wires. Fig. 56 shows the method where bushings are employed. If the entrance is made through conduit, the inner end of the conduit should always be extended to the service fuses. At the nearest accessible place in the building must be placed what are called the service fuses and the service switch. The switch is usually of the knife-blade pattern and must be such as to cut off all the wires. Single-pole switches must never be used as service switches. The purpose of service switches is to provide means for cutting off current for repairs or in case of fire or other accident. The service fuses should be placed between the service switch and the mains to the outside of the building. Their purpose is to protect all the wires inside the building from overloads, and they should be such as to melt or "blow" with current not much in excess of the normal full current likely to be taken by the entire installation which the service supplies.

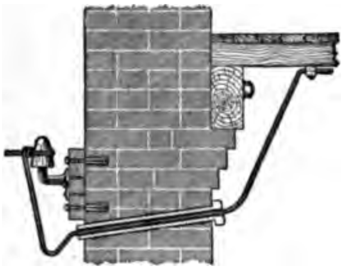

Fig. 56.* Method of Using Bushings

Service switches and fuses take many forms, from a pair of small "plug fuses" and knife switch on a porcelain base to quite elaborate switchboards which carry both these and other sub-fuses for the main circuits within the building. The same principle, however, applies to all; all wires must be protected, the service entrance must be accessible and fuses must be of proper capacity. From the service switch the lines usually extend through meters to distribution centers which are panels from which the several sub-circuits branch off to lamps or motors through the building. Fig. 57 shows such a center. There may be only one such center in a small installation, or in a larger one there may be a main distributing panel and numerous smaller ones at various places in the risk.

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*Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

General Rules on Wires. *Size.* No wire smaller than No. 14 B. & S. gauge is allowed (except in fixtures and for pendant or flexible cord) since no smaller size has both the conductivity and also sufficient mechanical strength to stand the strains of installation and use.

Joints and Splices. All joints and splices must be made both mechanically and electrically secure *and then be soldered* except when one of the very few approved splicing devices is used. For general wiring, the underwriters have never found any equivalent for *good* soldered joints when all the possible effects of corrosion, alternate heating and cooling, vibration, and mechanical strains are considered. The neatness and thoroughness of the soldered joints are two of the best general indications of the excellence of the workmanship on any job. After being soldered wire joints must be covered with an insulation equal to that at other places on the conductors. This is usually done by winding the joints with a good pure rubber tape over which is wound a "friction tape" of fabric impregnated with a compound.

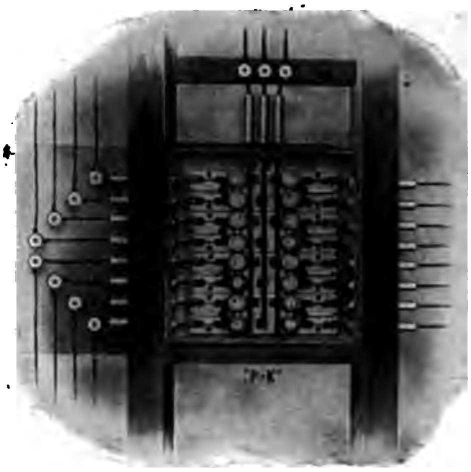

Fig. 57. Distributing Panel for Lighting Circuit

Wires in Walls, Floors, etc. Wires must always be separated from walls, floors, timbers, and partitions by non-combustible, non-absorptive, insulating tubes such as glass or porcelain and must be kept free from all contacts with pipes or any conducting material. This general rule is established without any reference to the insulation which is on the wires themselves, the idea being that the insulation of the conductors from each other and from other conducting materials must be sufficient to furnish the necessary protection in case the wire coverings are defective or become injured in any way. This principle does not, however, prevent the wires being drawn into metal conduits which are specially designed as wire raceways, nor can it apply to fixtures in which the wires must be in the metal stems and arms. For such cases special rules are established. Fig. 58 shows a good example of overhead wiring in which an iron pipe may be seen protecting wires up the post, while the wires on ceiling and around beams are very well arranged and supported.

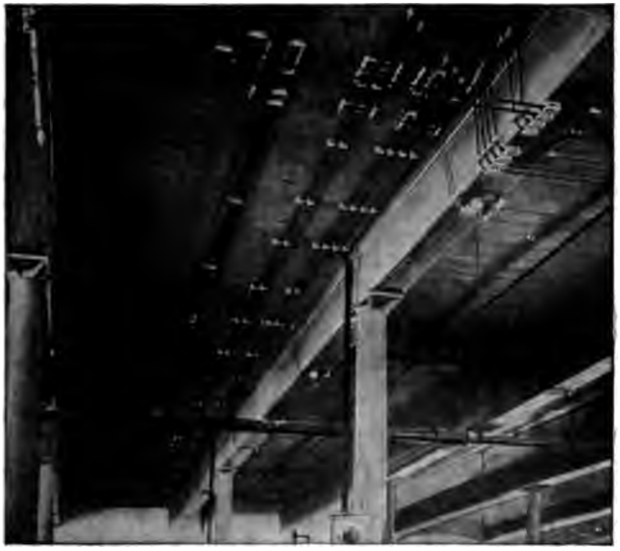

Fig. 58.* Approved Overhead Wiring

In damp or wet places, the relative arrangement of pipes and wires should be such that the wires cannot touch the pipes and so that water cannot drop from the pipes on the wires. The subject of electrical work in damp places will be considered in another place.

Carrying Capacity. The Code prescribes the maximum current which shall be carried on copper wires of different sizes. This table of carrying capacities has been unchanged for many years and was originally based upon an elaborate series of careful experiments. Table III gives the capacity for rubber-covered wires, and for all types of wire insulation such as slow-burning and weatherproof braids.

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*Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

The table for rubber-covered wires is lower than the other because high temperatures such as might result from a wire carrying too much current have a harmful effect on the insulating properties of rubber. The table is for indoor work only. It is stated that for any given size of wire, a current about three times as great as that given in Table III will cause all ordinary insulations to smoke. The table does not consider the question of *drop* as it is called. Thus in Fig. 59, suppose *D* is a dynamo supplying current to *M*, a motor 250 feet away from it, and suppose the motor requires 90 amperes at 220 volts. From Table III it is seen that No. 2 wire could be used. But some *power* is lost in driving the current through the 500 feet of line wire and, if the wire is small, its resistance will be large and so more power will be "lost on the line wires." The part of the dynamo voltage required to drive the working current over the supply wires is called the "drop." Suppose it is prescribed that the drop shall not be over 1 per cent of the total voltage. One per cent of 220 volts is 2.2 volts. The current in the line equals the voltage to force the current over the line divided by the ohms resistance of the line. In this case $90 = \frac{2.2}{\text{resistance}}$, or resistance of the 500 feet of wire must not be more than $\frac{2.2}{90}$ ohms or .024 ohms. From a suitable wire table it will be found that a No. 0000 wire will be required. Thus the necessity of keeping the loss of power low on the line may necessitate the use of a larger wire than would be needed for safety under the underwriters' rules.

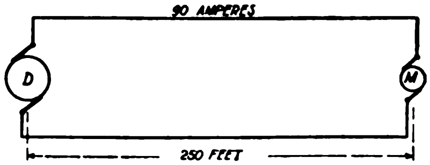

Fig. 59. Simple Electric Power Circuit

Constant-Current Systems. The nature of these has already been explained on page 13. Such systems are used nowadays almost exclusively for street lighting with arc lamps and the voltage runs

TABLE III

Carrying Capacity of Wires*

	Rubber Insulation	Other Insulations	
B. & S. G.	Amperes	Amperes	Circular Mils
18	3	5	1,624
16	6	8	2,583
14	12	16	4,107
12	17	23	6,530
10	24	32	10,380
8	33	46	16,510
6	46	65	26,250
5	54	77	33,100
4	65	92	41,740
3	76	110	52,630
2	90	131	66,370
1	107	156	83,690
0	127	185	105,500
00	150	220	133,100
000	177	262	167,800
0000	210	312	211,600
Circular Mils			
200,000	200	300	
300,000	270	400	
400,000	330	500	
500,000	390	590	
600,000	450	680	
700,000	500	760	
800,000	550	840	
900,000	600	920	
1,000,000	650	1,000	
1,100,000	690	1,080	
1,200,000	730	1,150	
1,300,000	770	1,220	
1,400,000	810	1,290	
1,500,000	850	1,360	
1,600,000	890	1,430	
1,700,000	930	1,490	
1,800,000	970	1,550	
1,900,000	1,010	1,610	
2,000,000	1,050	1,670	

*The carrying capacity of Nos. 16 and 18 B. & S. gauge wire is given, but no smaller than No. 14 is to be used, except as allowed under rules for fixture wiring.

from 2,000 to 3,300 volts. The arc lamps on such circuits are arranged so that each line has enough lamps in series to use the available dynamo or transformer voltage allowing the necessary margin for regulation.

The high voltages generally employed, call for the very best insulation and only rubber-covered wire should be used; all wires in buildings must be in plain sight and never encased. The bringing of such circuits into buildings is not very general and arc lamps designed to be connected in multiple on ordinary low-voltage circuits are much to be preferred.

There are special rules for series arc-lamp wiring in buildings which cover the method of bringing supply wires through the walls, provision for a special form of switch at points where the lines enter and leave the building, requirement for 1 inch separation between wires and the surfaces over which they pass and 8 inches from each other and extra protection of all wires by running boards or guard strips. The service switch required on constant-current systems must be a *double-contact* switch, that is, it must be so arranged as to first place a cross connection or short-circuit on the lines into the building and then disconnect these lines from the supply altogether. This leaves the circuit unbroken, but cut out of the building. An attempt to actually break the circuit would be sure to cause a very destructive arc. Series arc lamps must be carefully isolated from all inflammable stuff and unless they are of the "enclosed arc" type must be provided with screens and nets to prevent the escape of sparks from the carbon or melted copper. All connections must be made in a most reliable manner and in all series arc work it must be remembered that the voltage across any break in the circuit is very high and will cause very severe arcing.

Incandescent lamps are not generally connected to series circuits since their use involves an automatic cut-out at each lamp which will shunt the current around the lamp in case the lamp becomes loose or its filament breaks. These devices are expensive, difficult to keep in order and generally undesirable. Formerly, combinations of incandescent lamps on series circuits were used, consisting of groups of lamps in series or in multiple, but these arrangements are not now in use and are forbidden in the rules. It is evident that incandescent lamps on series circuits should never be

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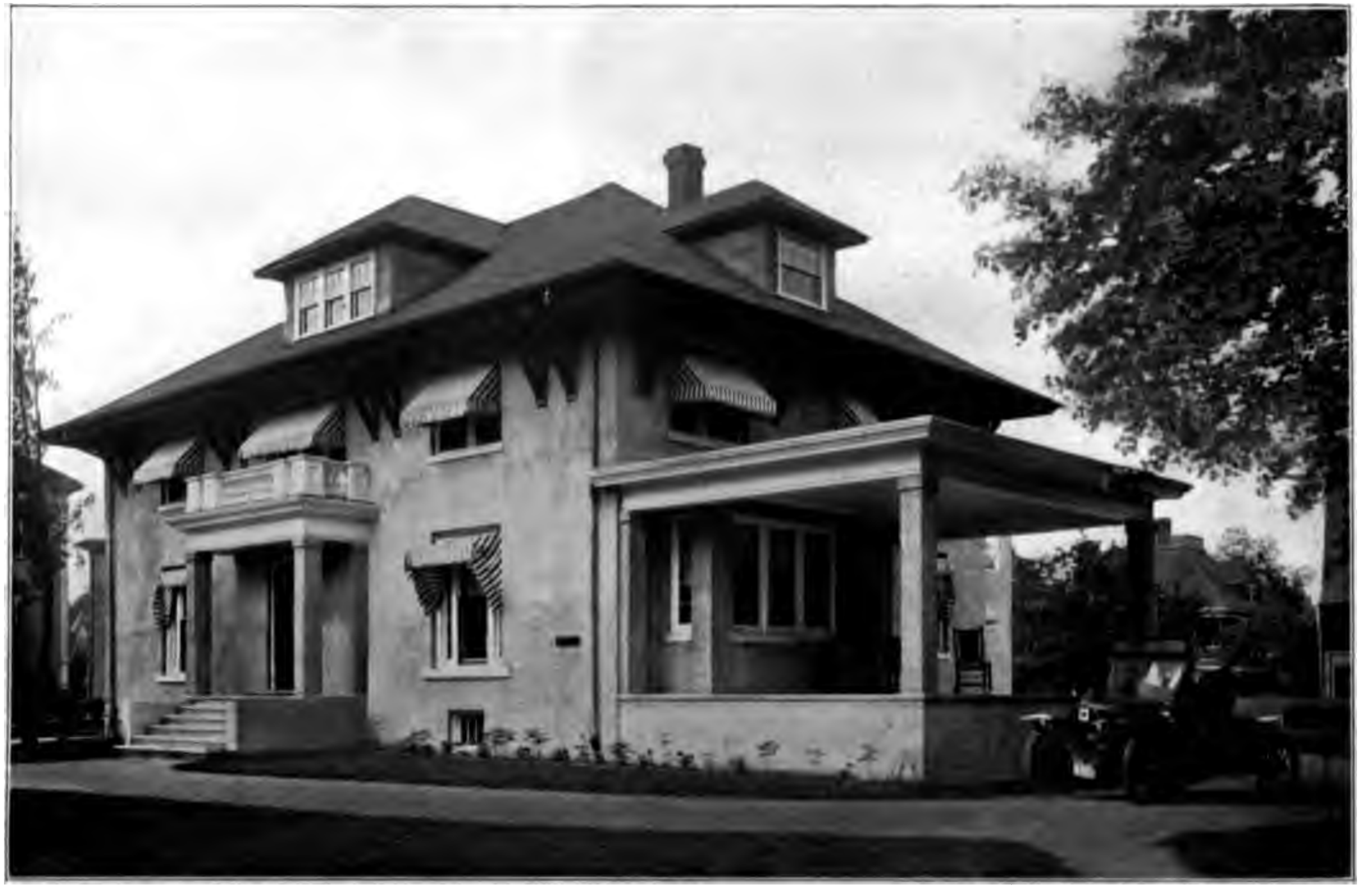

FIRE-RESISTING CONSTRUCTION OF HOLLOW TILE AND PLASTER
The Outside Walls Are of Ten-Inch Natco Hollow Tile. The Inside Construction Is Not Fireproof.
O. A. Thayer, Boston, Architect. Courtesy National Fireproofing Company, Pittsburgh

allowed on gas fixtures since an arc to the grounded gas pipe would be very severe and would be liable to burn through the pipe and ignite the escaping gas.

Constant-Potential Systems. The character of these systems has been explained on page 12. Almost all systems for light and power in buildings of all sorts are of this type. The most common are 110-volt two-wire direct-current systems; three-wire systems with 220 volts between outside wires and 110 volts between the neutral and either outer wire; 500- to 600-volt d. c. street and elevated systems with "ground return"; 440- to 600-volt a. c. systems for motors. In addition to these there are 1,100-, 2,200-, and 3,300-volt a. c. power circuits and the so-called a. c. transmission lines at all voltages from 1,000 up to 80,000 or 100,000 volts. While occasionally a. c. motors are made for direct operation at 1,100 or 2,200 volts, in general for voltages above 600 volts, alternating-current transmission lines are employed which are connected to transformers at the factories or mills where the power is used and which "step-down" the voltage to 440 volts or some other voltage which can conveniently be used in the motors and for lighting purposes. Both the primary and secondary circuits in this case are constant potential systems.

In street railway work large machines called rotary converters are employed which are driven by the high-voltage alternating current from transformers connected to the transmission lines and which deliver direct current at about 600 volts to the trolley system. Such rotary converters are usually placed in substations so located as to conveniently and economically supply the different sections of a city. A similar practice is followed in cities where direct current is to be furnished for general lighting and power, and the original generating station is more or less remote. Such substations come under the same rules as generating or dynamo stations.

All so-called isolated plants, that is, plants in individual factories or large buildings, are constant-potential systems also. In the underwriters' rules constant-potential systems are subdivided into *low-potential systems* 10 to 550 volts; *high-potential systems* 550 to 3,500 volts; and *extra-high-potential systems* over 3,500 volts. Of these the low-potential systems are of most importance since they include the very great majority of equipments for using electricity in buildings for light, heat, and power.

GENERAL INSTALLATION RULES FOR CONTROLLING AND PROTECTING DEVICES

Switches, fuses, and circuit breakers may all be described as arcing devices, that is, their operation always produces an arc. This arc may be small or large but it is impossible to break a circuit-carrying current without some arc even if it is so small that it is a mere spark. The duration and intensity of an arc depends upon the strength and voltage of the current, the rapidity with which the gap in the circuit is widened, and the design and condition of the arcing device, switch or fuse. Dust or inflammable gases may be ignited by an arc of sufficient intensity. No arcing device, therefore, should be placed near easily ignitible stuff, or exposed to inflammable gases, or dust, or flyings of any combustible material. When so exposed, as in flour mills, textile mills, etc., all switches and fuses should be enclosed in dust-tight boxes or cabinets. Open-link fuses are especially liable to flash violently and throw out molten metal and they must, therefore, be given special attention, and should never be installed outside of proper cabinets except on switchboards in fireproof rooms, such as engine rooms, generating stations, or where they will be under constant and expert supervision. Even in ordinary rooms, houses, stores, or factories, where there is no dust or combustible flyings in the air, it is much better to have all knife switches and all fuses placed in cabinets to prevent accidental short-circuits, caused by laying a metal object across the exposed parts.

Switches immersed in oil are in common use for large currents and are quite safe as regards arcing, though the oil involves a certain hazard since it is combustible.

It should be remembered that any switch or circuit breaker which is automatic, that is, which is not operated by hand by a person at the actual device itself, requires better protection since in case of failure the arcing may be severe and no one may be at hand to take the needful steps to prevent its starting a fire. Such automatic current-breaking devices including time-switches worked by clocks, sign flashers, and the like, should always be enclosed in very substantial non-combustible cases or cabinets of ample size and so arranged that they are not liable to be left open.

Switches. The general requirements for service switches have already been discussed. While it is true that the service switch and a switch for every motor are the only ones that are absolutely required by the rules, still convenience and economy of operation naturally call for a number of switches in practically every installation, and the correct placing of them becomes, therefore, a matter of importance. The description of some of the very numerous types of switches will be given later in this book, but we consider here the general rules for installing all types.

As a general principle, switches must always be placed in dry, accessible places and it is well to group them together so far as possible for the reason that this will often reduce the amount of wiring and also render it easier to use them in case of need.

Knife Switches. Knife switches consist of copper blades, one for each pole, hinged at one end to copper clips or posts and closing at the other into other clips. Where such a switch is made to close into clips at only one side of the hinge end it is called a *single-throw* switch and where the blades can be thrown into clips at either side of the hinge it is called a *double-throw* switch. Single-throw switches must always be installed so that gravity will tend to open rather than close them since otherwise they might fall and, by only partly closing, cause arcs and burning. Double-throw switches may be installed so that the throw is either vertical or horizontal as preferred. Fig. 60 shows a double-pole single-throw switch and a triple-pole double-throw switch correctly placed and a single-pole single-throw switch wrongly placed.

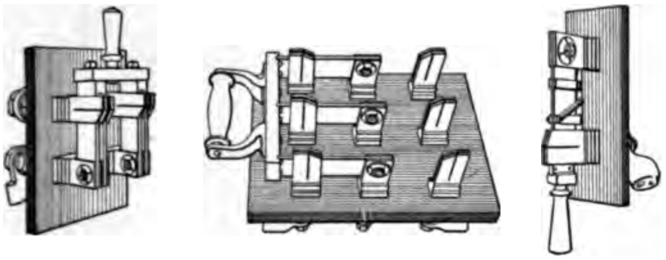

Fig. 60. Single, Double, and Triple Pole Knife Switches

Whenever practicable, knife switches should be so wired that the blades will be *dead* when the switch is open as this leaves less exposed live metal and also makes it easier and safer to make any repairs or adjustments of the switch blades and hinges. In Fig. 61 if the supply wires (from the service or dynamo) enter at the top and the lamps are connected from the bottom of the switch, the blades will be *dead* when the switch is open. If the arrangement is reversed, the switch blades will be connected to live wires all the time, whether the switch is open or closed. The illustration also shows an excellent type of cast-iron cabinet for such a switch combination.

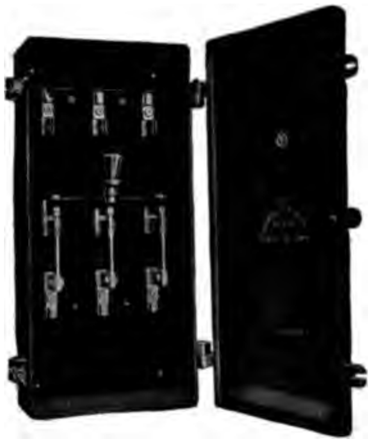
Fig. 61. Approved Metal Switch Box

Surface Snap Switches. These are the common porcelain base switches, usually round in shape and having metal covers with the operating handle at the center. They are commonly mounted on side walls and the wires are brought into them from the back. It is not possible to fasten them very securely to a lath-and-plaster wall unless some block is provided for the screws to be driven into. For this reason, wherever possible, at all switch or fixture outlets, a ⅞-inch block must be fastened between studs or floor timbers flush with the back of lathing to hold tubes, and to support switches or fixtures. When this cannot be done, wood base blocks, not less than ¾ inch in thickness, securely screwed to lathing, must be provided for switches, and also for fixtures which are not attached to gas pipes or conduit. Figs. 62 and 63 show these blocks with the wires brought through them and through the lath and plaster in short lengths of flexible tubing. The switches can thus be firmly screwed to the blocks and the wires connected to them.

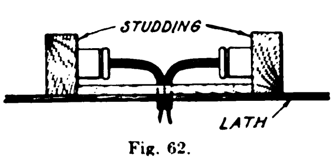

Fig. 62.

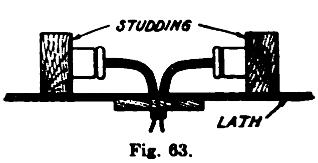

Fig. 63.

Proper Arrangement of Wires Passing through Lath-and-Plaster Partition

If snap switches are used with exposed wiring on cleats, there must be a porcelain sub-base under each switch so made that the wires will be kept ½ inch from the surface wired over. A similar sub-base must be used where such a switch is used with wood molding, but in this case it may be of hard wood instead of porcelain. Figs. 64 and 65 show how this is done.

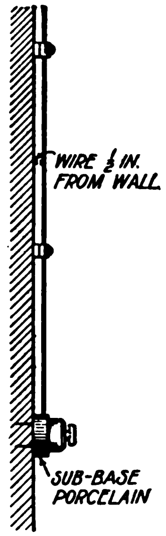

Fig. 64. Exposed Wiring on Cleats

Flush Switches. These are made to be inserted into walls so that only the operating push buttons or handle will extend out beyond the surface, and are now in very general use. Inasmuch as their operating parts are concealed in the wall they should invariably be set into small steel boxes through the back of which the wires may enter either through lengths of flexible tubing or through iron conduit. The same requirement applies to all small fittings such as receptacles from which flexible cords are run to heaters and other portable devices. Fig. 66 is a sketch of such a switch box set into a lath-and-plaster wall. The sketch shows the box as it would appear from the back of the wall.

Where it is desired to control the same electric lamps from either of two switches at different places, what are called *three-way* switches are installed. These are chiefly used in residences, as for the control of hall lights from either upstairs or downstairs. Under the rules these are classed as single-pole switches and are preferably wired so that only one main of the circuit is carried to either switch. Three-way switches are usually of the common round-surface porcelain-base type or push-button wall variety. Fig. 67 gives a diagram of the way to connect them.

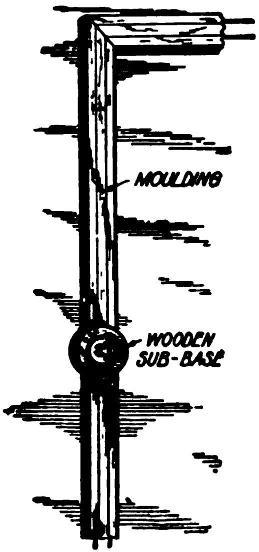

Fig. 65. Wires in Wood Molding

Fuses and Circuit Breakers. These may be compared with "safety valves" on steam boilers, that is to say, they are primarily designed to act in case of an improper condition of affairs and prevent by their automatic action any serious trouble resulting. Although this is the purpose of fuses and overload circuit breakers, it is altogether too common for users of electric current to misuse them, and so destroy the protection intended. It is evident that a fuse which is so large that it will not melt until a current passes through it which is far too large to be safely carried by the wires or other parts of the circuit, is worthless. The fusible part of a fuse is usually a strip or wire of soft lead or zinc of such size that if any considerable current over that for which it is designed passes through it, it will melt off and so open the circuit. Whenever a fuse of the proper size for its circuit *blows* or *melts*, the first thing to be done is to seek out the cause, for the operation of the fuse is *proof* that there is, or has been, something wrong. Thus if in a house a lighting-circuit is properly protected by 6 ampere fuses and these fuses blow, one may be sure that more than 6 amperes, and, therefore, *more than a safe current* has, for some reason, traversed the wires for a time long enough to melt the small fuse strip. Now, unless this excess of current was due to some momentary accident, known and recognized as such, the same condition that once allowed the unduly large current to flow probably still exists, and until this trouble is sought out and remedied, the same unsafe condition exists. It is, therefore, very unwise to replace the blown fuses with some of larger current-carrying capacity, for this is merely reducing the protection without removing the source of danger.

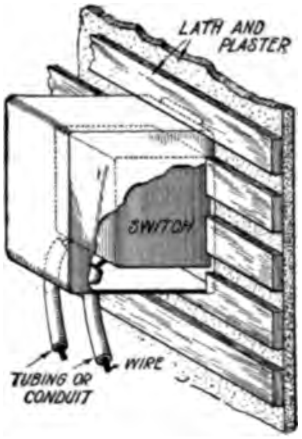

Fig. 66. Flush Switch Box in Lath-and-Plaster Partition

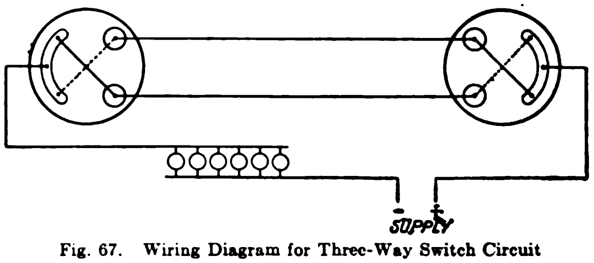

Fig. 67. Wiring Diagram for Three-Way Switch Circuit

Still worse is it to replace blown fuses by fuses which have been filled up with metal, or across, or through which, extra metal strips have been fastened in a misguided attempt to keep the fuses from blowing again. One might as reasonably tie down a steam boiler's safety valve. These principles when thus stated appear very elementary and self-evident and yet the misuse and abuse of fuses is, perhaps, the commonest fault observed in the maintenance of electric installations. The only reason that disaster does not always follow ignorant or culpable misuse of fuses, is to be found in the fact that wires and other parts of the system are installed with a fairly large margin of safety. This does not, of course, in any degree justify over-fusing circuits or tampering with fuses or other safeguards, and insurance inspectors should not tolerate any deviation from standard rules for the protection of circuits or fail to demand the use of only approved protective devices of proper rating for every circuit. Fig. 68 shows some fuses which have been "doctored" in ways unfortunately all too common.

The following excellent statement is taken from the book of rules of the Associated Factory Mutual Companies:

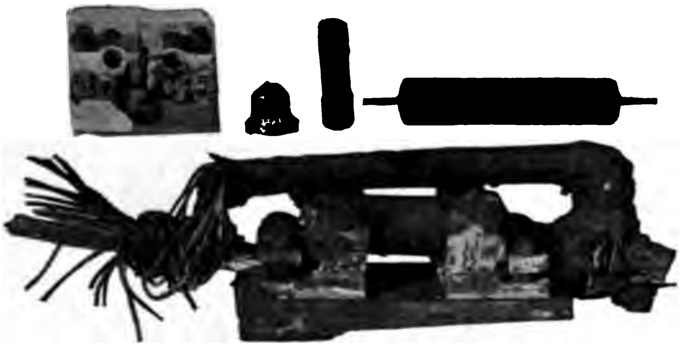

Fig. 68. Typical Examples of "Doctored" Fuses

> Specifications for fuses require that they shall be rated at a certain per cent of the maximum current which they will carry indefinitely, as follows: link fuses 80 per cent and enclosed fuses 90 per cent. The margin thus provided between the rating of the fuse and its actual melting point will permit the ordinary fluctuations in current without opening the circuit. If fuses selected to conform to the above rule are not large enough to carry the load, it is evident that the wires also are overloaded, and either the load should be diminished or the size of the wire increased.
>
> Circuit breakers are so sensitive that it is often necessary to set them much above the ordinary current to keep them from being constantly opened by momentary rises in the current, such as might be caused by starting a motor or by a rise in the voltage of the dynamo due to a sudden decrease of load.

When this is the case, a fuse may be necessary to protect the wire from a steady current above the safe carrying capacity of the wire but below the point at which the circuit breaker is set to open. The fuse requires a little time to heat, and so does not melt with the momentary rises of current which would open the circuit breaker if it were set as low as it would have to be if the fuses were not provided.

It has already been pointed out that "service entrances" must be fused, that is, there must be a fuse in each wire where the current supply is brought into a building. An exception is made in the case of three-wire (not *three-phase* a. c., however), systems. In these the fuse may be omitted in the neutral wire, provided this wire is of equal carrying capacity with the outside wires and is reliably grounded, since in such a three-wire system the neutral wire cannot under any condition carry more current than either of the outside wires; the fact that it is grounded adds a certain safety, because it is especially desirable that the neutral should not be opened unless the outside wires are also opened, as might occur if a neutral fuse alone blew, or was removed without the others also opening. Fig. 69 illustrates this point. When the fuse in the neutral at *N* is in place, lamps *A* can have only 110 volts across them and lamps *B* the same, but if the fuse *N* is removed, the group *A* will be in series with the group *B* across the 220 volts of the outside wires, and as there are 4 lamps at *A* and only 2 at *B*, the resistance and volts *drop* across *A* will be only one-half the resistance and drop across *B*. Thus *A* will get only one-third of 220 volts or 73.3 volts, and *B* will get 146.7 volts. The lamps *B* will thus burn *over bright* or even burn out, and those in *A* will be dim. Of course, if there were the same number of lamps at *A* as at *B*, it would make no difference whether the neutral wire were open or not, but when the system is *unbalanced* as in Fig. 69 it is better to avoid having the neutral opened and, therefore,

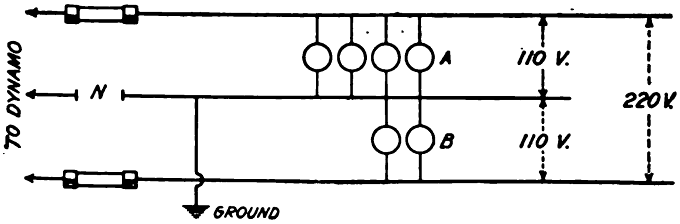

Fig. 69. Fuse Arrangement for Three-Wire Circuit

the fuse in it is often omitted, and the wire carried through unbroken.

Beyond the service entrance fuses and switch, the circuits are usually divided; thus in a house several circuits of smaller wire will lead to the lights on the different floors, or in a larger building or a factory, sub-mains will be carried up to the distributing centers through the building from which in turn smaller wires will branch out. The proper proportioning of these cables and wires for the economical distribution of current is a problem for the electrical engineer. The point to be noted here is that fuses or breakers must be placed at every point where a change is made in the size of wire unless the fuse next back will also protect the smaller wire. The rated capacity of fuses must not exceed the allowable carrying capacity of the wire as given on page 65, and circuit breakers must not be set more than 30 per cent above the capacity of the wire unless a fuse is also used when it may be set 100 per cent higher. Fig. 70 shows the sizes of wire and the fuse arrangement for a typical case. The arc lamps require 30 amperes, the 20 incandescent lamps 10 amperes, and the motor has a full load current of 20 amperes. The motor, however, must have leads for 25 per cent above full load current or 25 amperes or No. 10 wire. Allowing 60 amperes for the total normal current the service fuses at *A* might be 60 amperes and the wires next beyond them No. 4. The other wire sizes are shown and the fuses would have to be placed as shown and have the following

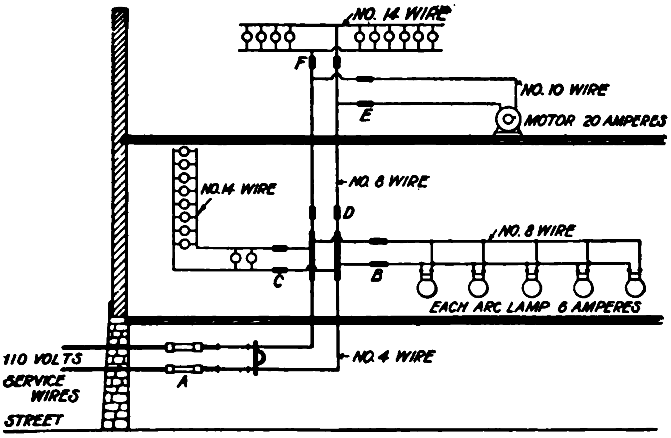

Fig. 70. Diagram Showing Fuse Arrangement and Size of Wire for Typical Lighting and Power Circuit

ratings: *B*, 30 amperes; *C*, 6 amperes; *D*, 30 amperes; *E*, 20 amperes; and *F*, 6 amperes. The 6-ampere fuses are required at *C* and *F*, because by a special rule mentioned below this is the limit for fuses for branch circuits at 110 volts supplying incandescent lamps. A pair of fuses is also required for *each* arc lamp and these would in the case shown usually be of a 10-ampere rating. If circuit breakers were substituted for the motor fuses at *E* they should be set to open at not over 30 per cent above the capacity of No. 10 wire or about 31 amperes.

It will frequently be found necessary to provide cut-outs where taps are taken from large mains. In such cases, if the clamps on the cut-outs are not sufficiently large and strong to give a firm and secure connection, a short length of smaller wire may be soldered to the main wire and then carried direct to the cut-out, which should be located as near as possible to the point of connection with the mains. Special care should be taken to guard these leads from accident as they may not be properly protected by the fuses in the main circuit.

Fuses are always installed in pairs (or sets of 3 on three-wire circuits), so that each side of the circuit is fused for the reason that a "ground" or "cross" might occur so as to cause a large current to flow over a path not including any fuse. Furthermore, fusing both sides gives a much greater factor of safety and insures protection under all conditions.

In installing incandescent lamps, fuses must be so placed that no set of lamps requiring more than 660-watts power will be dependent on a single pair of fuses. Some city rules state this in terms regulating lamp sockets or receptacles, and limit the number of sockets to 10 or 12 since this amounts to about the same thing. The purpose of this rule is to secure such a subdivision of the fuses that no very large currents can flow for any long time over any part of the small wiring without opening a fuse and thus the effects of a short-circuit or other accident will be very much minimized. Suppose we had a long line of No. 10 wire protected by 25 ampere fuses on a 110-volt circuit, and 50 incandescent lamps in multiple on this line with no other fuses. Suppose also that only one of the lamps were burning. Now if this lamp were hung on a flexible cord and a "short-circuit" occurred on the cord or in the lamp socket, we should have to wait until the short-circuit became severe enough to allow about 30 amperes of current to flow before the 25-ampere fuses would open. (All fuses will carry, for a short time, more than their rated currents.) But 30 amperes at 110 volts may cause an arc quite intense enough to set fire to the cord or cause molten metal to drop from the overheated socket. If the lamps were on a branch circuit of No. 14 wire protected by 6-ampere fuses, these fuses would probably melt before serious harm were done. Thus it may be seen that it is wise to subdivide the lamp circuits and protect each circuit with small fuses. In exposed wiring in large mills an exception is made permitting incandescent-lamp circuits with 25-ampere fuses to be used provided *each lamp* is protected by a very small fuse placed in a ceiling rosette. This is allowed to prevent running an excessive amount of wiring through large rooms where the crowded wires might be themselves a source of danger. It was formerly the custom to place small fuses in the canopies of fixtures or ceilings and side walls but they were always troublesome and dangerous to an extent that did not offset the slight extra protection they afforded and all such "bug" fuses have long been forbidden.

Enclosed fuses, plug and cartridge, are allowed by the Code rules to be installed without cabinets except in dusty or linty places but some municipal ordinances require *all* fuses to be in cabinets. While this is safer, there would be a tendency to use the open-link lead fuse everywhere if cabinets were universally required since they are much cheaper than enclosed fuses, and this is a tendency not to be encouraged. If proper locations are chosen for enclosed fuses and if only approved fuses are used, there is little hazard under ordinary conditions. Enclosed fuses either of the cartridge or the plug type and of makes having the underwriters' approval will open the circuits for which they are rated with practically no explosive action and without emitting flame or molten metal even on heavy short-circuits. Even so, however, they should never be placed near combustible material.

Electric Heaters. Under this heading are included all devices in which use is made of the heat developed by the current (usually by causing it to pass through coils of wire). These are electric pressing irons, air and water heaters, toilet articles, such as curling irons, cooking devices of all sorts, and a vast and constantly increasing variety of domestic and industrial appliances. All these present the same hazards as other heaters of equal capacity, except that the dangers of open gas flames and of matches are eliminated, and they all require the same precautions in use and in their installation. Each should be protected by fuses either on the device or preferably in the branch circuits supplying them and must be controlled by separate switches so made as to indicate whether the current is "on" or "off." These must be double-pole switches if more than 660 watts of energy is required. In general, such heaters should never be "built in" but should be in plain sight. However, for many industrial purposes electric heaters are constructed as parts of tools or machines and when well made and used with due care are not more hazardous than other methods of heating.

Portable heaters are in general more dangerous than stationary ones since the latter may be safeguarded by suitable heat-resisting material placed between the device and its surroundings, such as sheets of tin or steel with an air space between them or by alternate layers of sheet steel and asbestos with a similar air space.

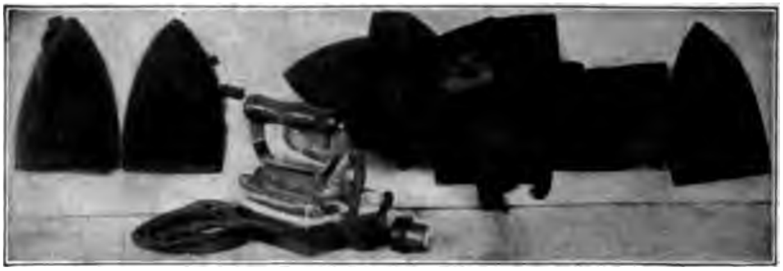

Fig. 71. Effects of Careless Use of the Electric Iron

The electric flatiron is perhaps the cause of more trouble and danger from fire than any other form of heater. The temperature of the iron required for ironing damp fabrics is necessarily high (at least 500° F. is common) and if the iron is left with current *on* and is not in use it will become red-hot in from ten to twenty minutes. If it has been left on a table or on clothing a fire is almost inevitable. Fig. 71 shows a cloth-covered board burned by electric irons. Few irons have any automatic cut-off to guard against such an accident and the fact that many such irons are used by persons not familiar with the possible danger, makes these devices rather hazardous.

It is often desirable to connect in multiple with the heaters and between the heater and the switch controlling same, an incandescent lamp of low candle power, as it shows at a glance whether or not the switch is open, and tends to prevent it being left closed through oversight. An approved stand, of a pattern such that the iron may be safely left on it even with the current on, should be used with every electric pressing-iron. The ordinary plain iron stand for cast flatirons is not adequate as it will become hot enough to set fire to a table. It should be remembered that stove-heated irons get cooler when taken from the stove, while an electric iron will get hotter and hotter if left connected to the circuit and not used. Fig. 72 shows an iron properly installed with indicating switch, pilot lamp, and stand.

Portable heaters, if they require over 250 watts, should be furnished with approved "heater cord" which consists of stranded copper conductors with a thin rubber and a thick asbestos yarn covering over each with a good braid over all. In factories and shops where a large number of flatirons or rather portable electric heaters are used, the circuits leading to them should be so arranged and provided with switches that any department or tier of benches can be cut off when not in use and pilot lamps in conspicuous places should be provided to call attention to the fact that the circuit is closed to the heaters. Domestic cooking devices electrically heated, are, in general, fairly safe as made by well-known manufacturers, and are preferable from the viewpoint of fire hazard to similar appliances heated by gas or by alcohol lamps.

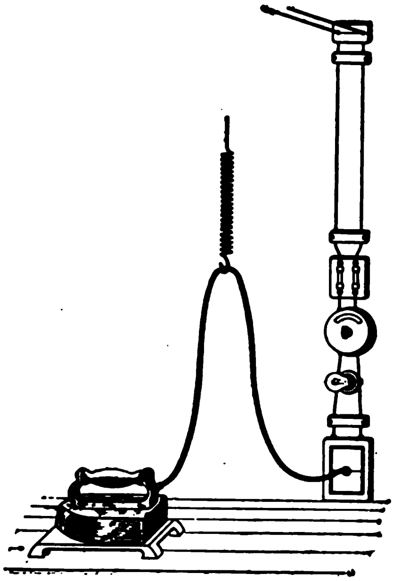

Fig. 72. Properly Installed Electric Iron Circuit

The use of flatirons or other heaters on ordinary lighting circuits is undesirable since they often require more current than can be taken through the proper fuses for such lamp circuits. It is very desirable that special circuits be run of large wire properly fused and with large capacity fittings and that all heating and small power devices such as washing and vacuum cleaning machines be supplied from such special circuits. The ordinary wall or ceiling fixtures and the lamp sockets attached are very ill suited for connecting portable heaters because of their lack of current-carrying capacity; and, too, because they are not mechanically strong enough to withstand the comparatively rough usage to which they are inevitably subjected.

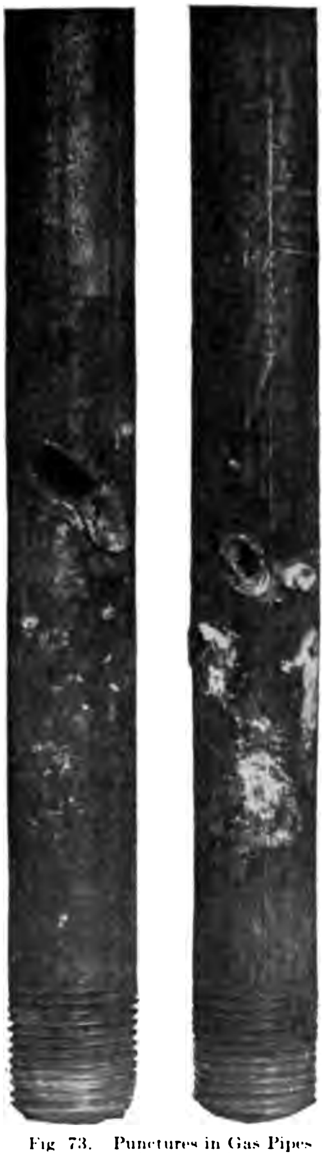
Fig. 73. Punctures in Gas Pipes from Short-Circuits

FIXTURES AND FIXTURE WIRING

Fixture Details. Electric fixtures are of two types known as straight electric and combination, the former carrying only electric lamps and the other having both electric and gas lights. The chief parts of a fixture are the canopy at ceiling or wall, the stem, the body, the arms, and the sockets. Most fixtures consist of plain iron pipe, often of small size, threaded into special castings in the body or central ball with arms branching from the body. Over this pipe body is a casing of brass pipe in pressed or spun forms. In straight electric fixtures the wires are usually drawn through the iron pipes, but in combination fixtures the gas runs in the pipes and the wires lie along the outside of the pipes between them and the casing or are drawn through cored holes in cast-brass arms. The necessarily small spaces and channels for wires in fixtures and the slight amount of insulation which the wires can carry, require very careful work in order that the best conditions possible may be maintained. The pipes in which wires are drawn should be carefully reamed at ends and all sharp angles, burrs, and corners on which wires may be injured should be carefully rounded off. These details should be attended to by the fixture maker but are often neglected, resulting in such accidents as are shown in Fig. 73, where the current has burned holes through the gas pipe and ignited the gas. Nothing but rubber-covered wire having a rubber wall, and no wire smaller than No. 18 B. & S. gauge, should be used. Stranded wire is preferable to solid wire. A rubber insulation $\frac{1}{64}$-inch thick is permitted on No. 18 wire for fixtures, but all No. 16 wire and all flexible cord if used for fixture work should have at least $\frac{1}{32}$-inch wall. Fixtures are not allowed on circuits of over 300 volts. .

Insulating Joint. On lath-and-plaster ceilings and walls where steel outlet boxes are not used, fixtures are usually fastened to some form of "crowfoot," a small tripod casting into which the stem of the fixture is screwed. Combination fixtures are screwed on the projecting nipple of the gas pipe. When fixtures are thus supported on gas pipes or when they are attached to any grounded metal work of a building or are on walls or ceilings of plaster on metal lathing, an approved "insulating joint" must be inserted between the fixture and its support. An insulating joint is a coupling, the two ends of which are reliably insulated from each other by some substance, usually mica. For combination fixtures there is a hole for the gas through the center of the joint. Such joints are required to be made of materials which will not be affected by the gas; no soft rubber is allowable and they must be capable of withstanding a voltage test of 4,000 volts a. c. between the two ends. Such insulation is required because the fixture wire is necessarily poorly insulated and liable to permit the conductors to become "grounded" on the fixture at one or more points. The insulating joint prevents such a failure in the fixture from causing current to flow to the earth in case the circuit is either purposely or accidentally grounded at other places. It also prevents voltage sufficient to puncture the fixture wiring from arcing across broken insulation to the fixture and so to the ground.

Canopy Insulators. Since the canopy or bell covering the base of the fixture at the ceiling or wall is in electrical connection with the fixture stem, it also must be insulated at its upper edge from the wall wherever an insulating joint is required. Canopy insulators take the form of molded rings of composition, fiber rings riveted to the canopy edge or insulating linings and flanges of micanite or other suitable material. Fig. 74 shows a correctly mounted combination fixture with insulating joint and canopy insulator. The cut also shows the pieces of flexible tubing in which the wires are separately encased from the last porcelain support, through the ceiling and to a point below the insulating joint. *B* in the figure is a piece of insulating tubing which should be placed about the gas pipe above the insulating joint. In case the wires were in steel conduit a steel outlet box would be placed in the ceiling, the gas pipe would enter through a central hole in the back and the conduit through another hole at one side. In such cases the flexible tubes would not be used but the canopy insulator and the insulating joint would still be required. Most trouble from fixtures occurs in the canopy from poorly made wire joints and crowded or jammed wires which gradually give way until finally an arc is formed and the wire coverings are ignited, Fig. 75. Canopies are often made too shallow and too small and workmen are often careless in connecting fixtures.

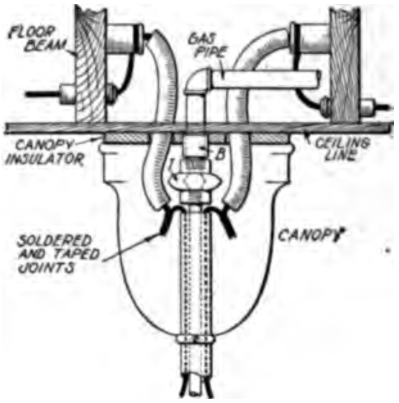

Fig. 74. Correctly Mounted Combination Fixture

Sockets and Receptacles. These are the devices into which incandescent lamps are put and are today made in a great variety of forms. The most common is the familiar brass shell socket either with a key switch or keyless, screwed on the ends of fixture arms or hung on flexible cords. Where a lamp holder is desired to be fastened rigidly to walls or ceilings, receptacles are used and this in general constitutes the distinction between receptacles and sockets. For outdoor use or in damp places weatherproof sockets or receptacles should be used. These usually have porcelain or composition outer shells, with connecting wires sealed in or with some form of encased terminal so placed and covered as to keep moisture from exterior and interior.

It is good practice to use only porcelain sockets in locations where a person might touch them while at the same time in contact in any way with any grounded metal work. Thus in bath rooms if a person attempted to turn on a lamp by means of the key of a brass covered socket while at the same time he was touching a water pipe or faucet, he might receive a painful or dangerous shock if any portion of the electric circuit were grounded. While such a shock would not be given, if everything were in proper condition, still there are numerous instances where persons have been killed and it is certainly wise to prevent even the chance of such an accident by either using all porcelain sockets or by putting the sockets out of reach, and controlling the lamps by means of a switch on a side wall. This practice is especially to be commended where the lamps are supplied with a. c. transformers the primaries of which are supplied by circuits

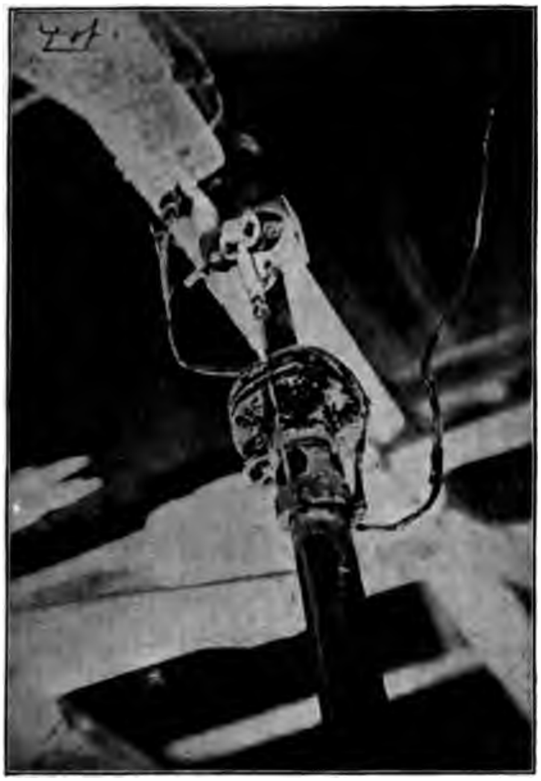

Fig. 75. Result of Defective Fixture Insulating Joint

of voltages of 1,100, 2,200, or higher values. The voltages of 110 or even 220 either d. c. or a. c., which are almost universally used for incandescent lighting indoors, are not of themselves at all liable to injure persons, but if there is a fault in the transformer the high primary voltage may get into the house over the secondary lines and such a circuit will then be distinctly dangerous to life.

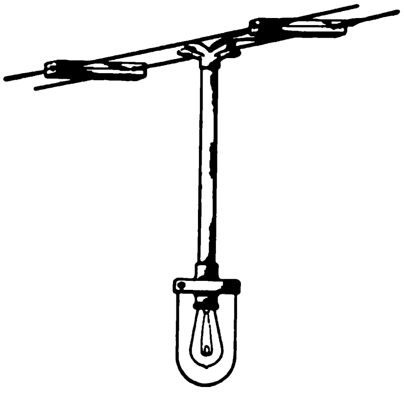
Fig. 76. Enclosed Incandescent Lamp as Precaution Against Explosive Vapor

In rooms where inflammable gases may be present, as the result of some manufacturing process or otherwise, the incandescent lamp and its socket must be enclosed in a vapor-tight globe and supported on a pipe hanger, wired with approved rubber-covered No. 14 wire soldered directly to the circuit wires. Even the minute spark caused by breaking a 16-candle-power lamp has been known to set fire to vapors such as gasoline and air in the proper mixture and the reason for taking every precaution against sparks where such vapors exist, becomes very apparent. Fig. 76 shows a lamp so enclosed and supported.

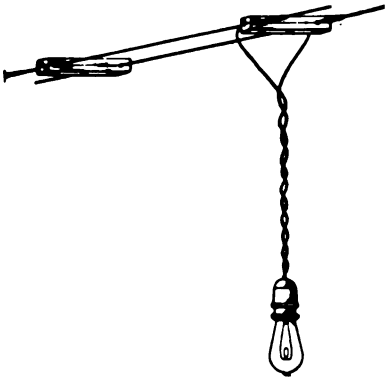
Fig. 77. Flexible Cord Mounting for Incandescent Lamp

In damp or wet places weatherproof sockets are required and these must either be made upon fixtures or hung as shown in Fig. 77. Here stranded No. 14 rubber-covered wires are shown passing from the socket to the circuit wires to which they are soldered. The socket and lamp must not hang direct on the soldered joints but some other support must be supplied as by holding the socket wires under one of the porcelain cleats. The ordinary brass shell socket is a fairly standard device as now furnished by the best makers, but it is of necessity small, and not very strong. It is decidedly better never to use such a socket except for an incandescent lamp and where an outlet is desired from which to take current for portable heaters, fans, and the like, to provide special wall or floor receptacles. This insures adequate current-carrying capacity and avoids mechanical injury to the comparatively frail sockets.

Flexible Cords. There are two chief classes of flexible cords, the plain twisted pairs and the various types of reinforced cord for portable use and where extra protection and strength is needed. It will be observed that the use of *any* type of flexible cord constitutes an exception to the general rule that conductors must be well separated. From one point of view it seems inconsistent to require wires to be well separated in walls, floors, and partitions and then permit the two conductors of a cord to be twisted closely together, with only a thin rubber insulation and a cotton braid on each. It is, in fact, a concession made to the necessities of the case and it cannot be denied that flexible cords may be and often are the weakest part of an ordinary wiring installation. It thus becomes at once evident why very definite limitations must be made in the use of cords. Fig. 78 shows types of flexible cords.

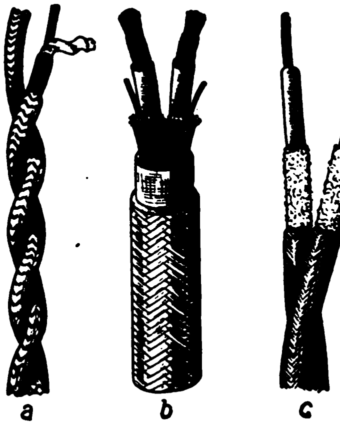

Fig. 78. Types of Flexible Cords

The common "twisted pair" cord consists of stranded copper conductors having a total carrying capacity equal to that of No. 18, 16 or 14 B. & S. gauge solid wire. No conductors smaller than No. 18 are allowed even for very small currents in order that the mechanical strength may not be too little. (It should be noticed also that No. 18 and No. 16 wires are permitted only for flexible cord and for fixture wiring, No. 14 or larger being required everywhere else.)

The copper strands are twisted or cabled together and wound with a wrapping of cotton thread both to keep the rubber from direct contact with the copper which it tends to corrode and to prevent a broken strand of wire puncturing the insulation.

The rubber insulation should be $\frac{1}{32}$-inch thick on No. 18 and No. 16, and $\frac{3}{64}$-inch on No. 14 cords and over each should be a fairly close braid of cotton thread. It is apparent that the finished cord so made with its two conductors twisted closely together does not afford any very great protection against a short-circuit resulting from broken or worn insulations and braid, and that the rubber and cotton braids supply a very fairly good fuel for any flame which is started.

The foregoing is not intended to lead to the conclusion that flexible cords should not be used, but rather to point to the reason why their use should be restricted and why they are open to objections not applying to ordinary separate and fixed wires.

Flexible cord should never be used as a substitute for regular fixed wiring. If the wiring provided does not give outlets at the proper places it should be changed in a proper and reliable manner. The common practice of festooning flexible cord along walls and ceilings and even through doorways and walls is to be strongly condemned as an unsafe and wholly inexcusable misuse of material. The use of flexible cord is limited to 300 volts. It should not be used to support lamp clusters as they are not capable of being secured well enough under binding screws to hold any considerable weight. The ordinary cord should be used only to hold lamps which under all usual conditions hang freely in air and which are not likely to be moved sufficiently to come into contact with surrounding objects. In brief, this cord is for "pendant" use only as its common name implies. The use of pendant cord for reinforced cord is a very common fault. Ragged half-broken lamp cord lying about on floors and looped over all kinds of supports constitutes a very common defect in installations, otherwise perhaps in fair condition. "Flexible cord fires" are as common as might be expected from the frequent misuse of this form of wire.

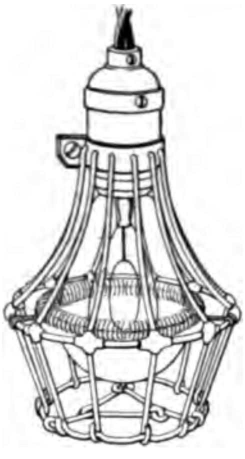

Fig. 79. Wire Guard for Portable Lamp

For all portable work including those pendants which are liable to be moved about, some form of reinforced cord should always be employed. In these the ordinary pendant cord is covered either with an outer rubber jacket and a stout "over-all" braid or where the exposure to injury is less (as in offices and residences) with an outer woven braid only. These reinforced cords are far from indestructible and should be frequently inspected and renewed before an accident makes it absolutely necessary. The use of all kinds of flexible cord in show windows is expressly forbidden by the Code, because it has been found that it is subject to exceptionally hard usage there, and more especially because of the practical certainty that it will be used as a support for window decorations or goods of inflammable nature which have often been found *pinned* to it or supported by wires strung across it. A special kind of cord having a metal armor is, however, allowed in show windows.

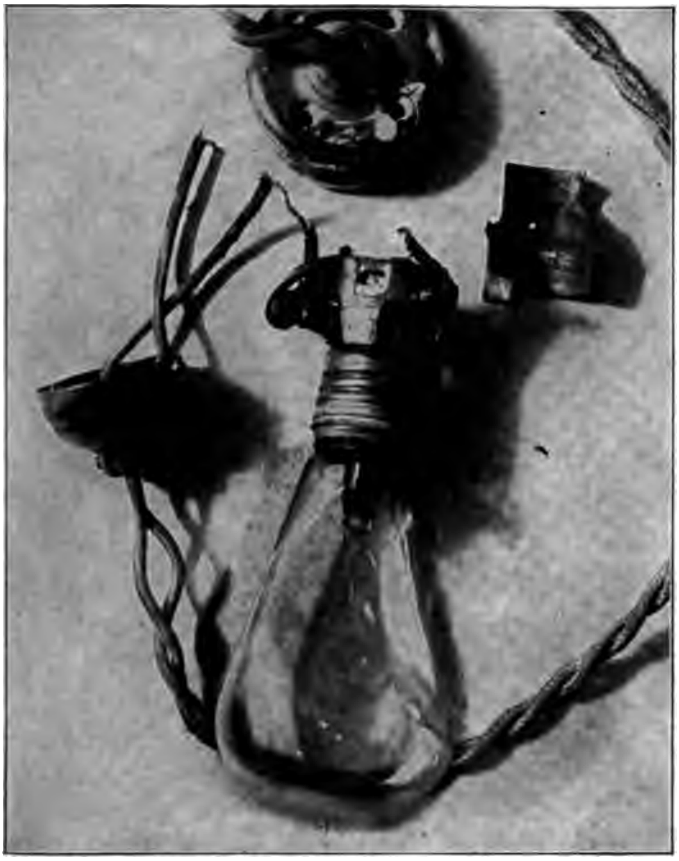

Fig. 80. Results of Careless Handling of Portable Lamps

In connecting flexible cords to sockets, rosettes or other devices, special attention should be paid to seeing that all the small copper strands are well tucked in under the heads of binding screws and that stray ends are not left sticking out to cause short-circuits. At all places where cords pass out of sockets or other fittings, smooth, well-rounded insulating bushings should be provided and a knot should be tied in the cord inside the socket cap or rosette, so that this knot will take the strain from the binding screws. Several special little fittings for this purpose are also on the market as substitutes for the knot. Pendant lamps wherever exposed to injury or at all liable to be brought into contact with inflammable material, and *all* portable lamps should be provided with substantial wire guards such as are shown in Fig. 79. Figs. 80 and 81 show the results of carelessness with hanging or portable incandescent lamps.

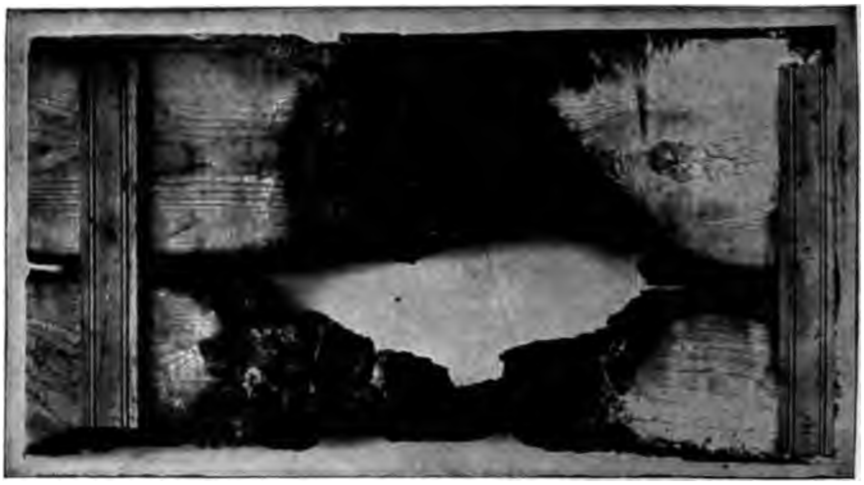

Fig. 81. Hole Burned by Incandescent Lamp Bulb

Arc Lamps on Constant-Potential Circuits. Each lamp, or each series of lamps, should be separately fused and the branch conductors should have a carrying capacity about 50 per cent in excess of the current required to provide for the heavy current required by the lamp in starting or when the lamp carbons accidentally become stuck. If this were not done it would be necessary, generally, to over-fuse the wires, which is objectionable.

Arc lamps are of many patterns but all of them contain resistances or regulators which become very hot and, therefore, all the parts of the lamp and its case must be of non-combustible material and must be treated as sources of heat, that is, they must be installed well away from all inflammable stuff. The globes and netting about the carbons must be used in all cases. In general the resistances and all other accessories of the lamp except the controlling switch should be contained in the lamp case itself. Fig. 82 shows a modern type of enclosed arc lamp and its mechanism.

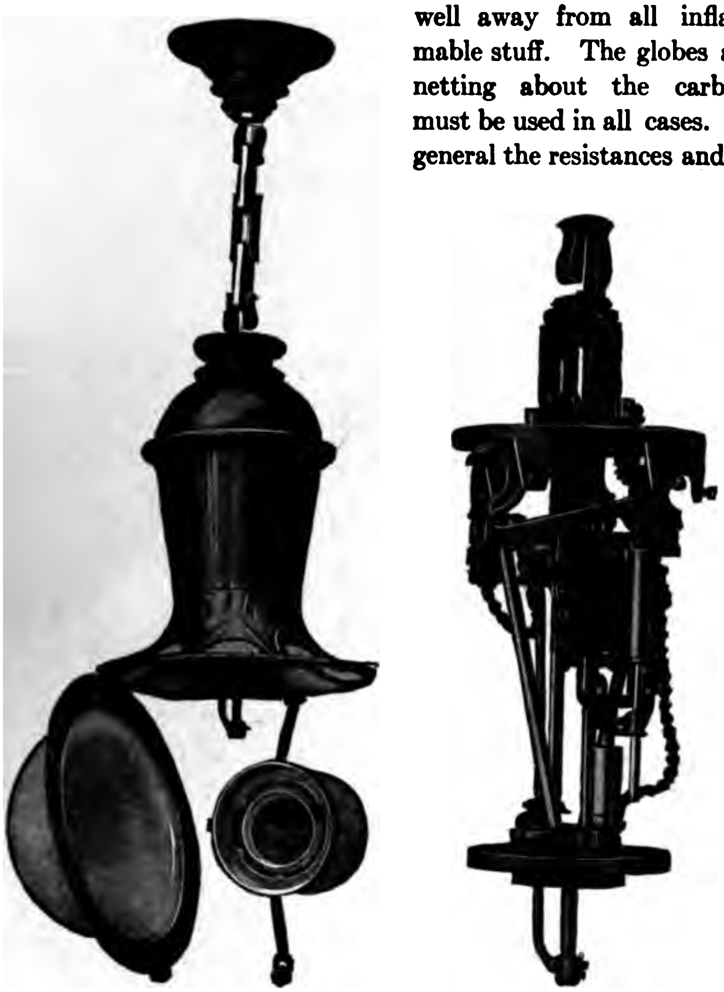

Fig. 82. Exterior and Interior View of Enclosed Arc Lamp

The "flaming arc" lamps now in common use call for the same precautions as the older patterns. In dusty or linty places special precautions must be taken to prevent the accumulation of lint, etc., either on hot resistances, inside the lamp or on the switch usually furnished on the lamp. In general the same rules apply to mercury arc lamps as to the carbon arc lamps, except that the former do not present the hazards due to the hot carbon points.

TRANSFORMERS IN BUILDINGS

Except in central stations and substations, an outside location for transformers is always preferable and the underwriters do not allow any oil-cooled transformers in buildings except by special permission. This is because of the danger from the oil which may be boiled over or set on fire in case the transformer becomes overheated.

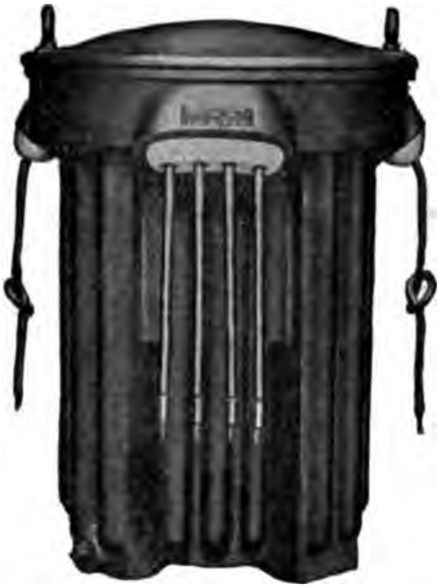

Fig. 83. Common Type of Oil-Cooled Transformer

Air-cooled transformers having the highest voltage of both primary and secondary under 550 volts may be installed inside buildings if the case is kept at least one foot from combustible material or separated from such material by being mounted on a suitable slab of slate or marble. Transformers sometimes become very hot in case of a partial or complete burn-out of the coils or from overloading and, therefore, should never be mounted directly against wood posts, beams, or walls. Fig. 83 shows a common type of oil-cooled transformer.

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UNDERWRITERS' REQUIREMENTS

PART II

INSTALLATION OF WIRES IN BUILDINGS

The proper choice of wires and their safe installation constitutes the most important part of all electric equipment from the viewpoint of the fire hazard. It has already been stated that in all electric work, conductors, however well insulated, should always be treated as bare, and from one point of view, it may be said that the value of conductors as regards safety lies in their insulation rather than in the copper, for if we assume that a wire of adequate carrying capacity is chosen for a given purpose, there remains only the choice of a suitable covering or insulation on the wire and a reliable and workmanlike method of placing it.

No one material has yet been produced which has every desirable property as a covering and insulation of electric wires and cables. Among the desirable properties of a wire covering are elasticity, flexibility, waterproofness, good insulating quality and resistance to voltage strains, resistance to effects of changing temperature, acids, vapors, etc., and permanence. All of these properties are possessed by rubber in greater or less degree and, all told, to a greater degree than any other material. The properties of rubber-covered wires will be treated at greater length in another place, the foregoing statement being made here to emphasize the reason why rubber-covered wires are used almost exclusively in all inside wiring.

"Slow burning" wire is a copper conductor covered with three closely woven cotton braids saturated with a fire-resisting compound. Its use is limited to places where rubber is liable to be rapidly injured by high temperatures. Its insulating value is slight and it is not capable of resisting moisture.

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"Weatherproof" wire consists of a copper conductor covered with three braids saturated with a moisture-proof compound. Its insulating value when new is low (much less than rubber) and it is very inflammable. Its use is practically confined to outdoors.

In the following sections it may be assumed that all references to wire mean "rubber-covered" wire.

Classification and General Principles. There are two classes of wiring which may be named for convenience: *enclosed* wiring and *non-enclosed* wiring.

Wires run on insulators such as cleats and knobs exposed on walls and ceilings or on knobs and through tubes concealed in floors and walls are the chief types of non-enclosed wiring. It will be observed that the distinction consists in the presence or absence of special wire-ways or channels for the wires. Wires must not be laid in plaster, cement, or similar finish, because such materials may contain either alkalies or acids which will injure the insulation and corrode the copper. Wires must never under any circumstances be fastened with staples because of the probable injury to the wire coverings, the insecure fastening obtained, and the possibility of such staples affording a path between wires in case twin conductors are used.

Twin wires must never be used except in conduit or where flexible conductors are necessary. The nearness of the two wires, on the opposite sides of the circuit, renders twin wire of any description somewhat more liable to failure and an injury to one wire generally involves an injury to both with resultant certainty of a short-circuit. The added safety of keeping the wires of a circuit separated is lost in twin wires.

In any scheme of wiring it is essential that all electric wires be installed so that they cannot come into contact at any point with any materials other than those expressly intended for their enclosure or support. This means that they should be kept absolutely free from contact with gas, water, or other piping, and from all metal work of any description unless it be that of piping, boxing, or molding provided as wire enclosures. Wires should also be installed so as not to touch woodwork or other combustible material, even if such material is not a good conductor. This general principle finds an exception in the case of wood molding.

Contact of wires with metallic substances may, in case of a failure of the insulation, permit dangerous arcs, short-circuits, or grounds, while contact with wood or combustible material is objectionable on account of setting fire to it in case of overheated wires or from leakage due to the presence of moisture on materials which when dry would be good insulators. These are, therefore, the general principles of wiring under the established rules and will be illustrated in the discussion of the various classes of wiring which follow.

Open Work in Dry Places. Wires in open work may be either rubber-covered, slow-burning, or—special and now little used wire having a weatherproof braid covered by a slow-burning braid—but as a matter of fact only rubber-covered wire is used to any extent and it is much to be preferred except in exceptionally hot places as over steam boilers, where rubber insulation will deteriorate very rapidly. The rubber-covered wire used for open work has a single braid over the rubber. The chief advantages of open work are its cheapness and its accessibility. The latter may be of great advantage in cases where frequent changes and additions are likely to be required or where renewals of wire are frequent because of peculiarly unfavorable conditions such as exist in packing houses.

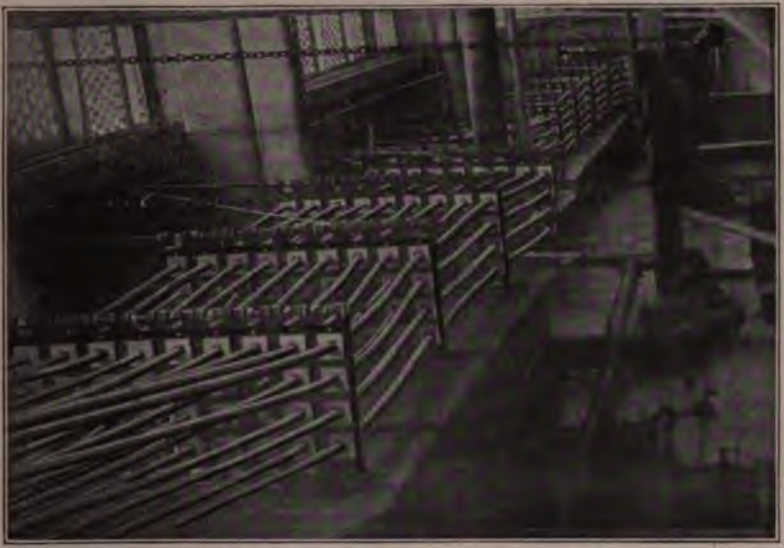

Fig. 84. Large Feeder Wires Exposed on Insulators

Open work finds its chief use in mills and factories and for large conductors which it is especially difficult and expensive to enclose in conduit. Fig. 84 shows an example of a set of large feeders run exposed on insulators. It should be noted that such a large group of heavy cables covered with the inflammable braid and rubber insulation furnishes a very considerable amount of fuel for fire and the necessity for excellent spacing and reliable fastening is obvious. The heavy porcelain blocks carried in metal frames as shown in the illustration are of an approved type. In all open work, wires or cables must be rigidly supported on non-combustible, non-absorptive insulators. Formerly wood cleats were used but these are now obsolete and have been replaced by porcelain. Where the voltage is less than 300 volts, wires must be separated from each other at least 2½ inches and from the surface wired over at least ½ inch in dry places—in damp places at least 1 inch. For voltages from 301 to 550 volts, the limit for "low-potential systems," the wires must be kept 4 inches apart and 1 inch from the surface wired over.

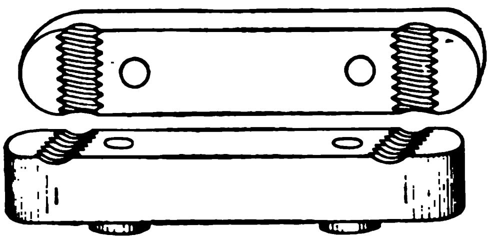
Fig. 85. Porcelain Two-Wire Cleat

The neutral wire of an Edison direct-current three-wire system (110-220 volts) may be placed in the center of a three-wire cleat which will keep the two outside wires 2½ inches apart. Fig. 85 shows the form of a porcelain two-wire cleat and Figs. 86 and 87 show good

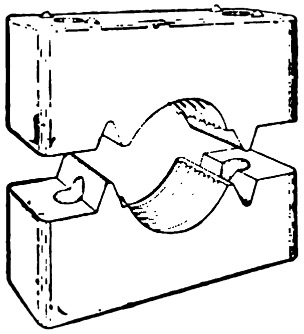
Fig. 86. Porcelain One-Wire Cleat

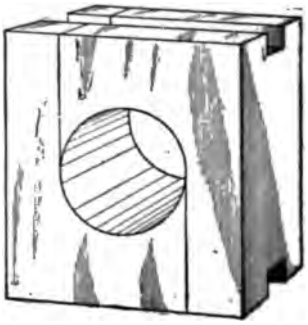
Fig. 87. Porcelain One-Wire Cleat

forms of one-wire cleats for heavier conductors. No. 6 wire is about the largest which should be installed in cleats like those in Fig. 85, and for cables larger than No. 0000 B. & S. gauge, some form of iron rack for the insulators is desirable in order to secure the needed mechanical strength and rigidity.

The rigid supporting necessary for open wiring requires under ordinary conditions along flat surfaces, supports at least every 4½ feet. This distance should be decreased wherever wires are liable to be disturbed especially if the wires are small. The following comment is from the Rules of the Associated Factory Mutual Fire Insurance Companies:

> The proper distance between insulators depends largely on the surroundings. In places where ceilings are low, or where belts, shafting, or other machinery may require frequent attention, insulators should be placed every few feet, in order to prevent the wires from being displaced by careless or unavoidable blows from workmen. On the other hand, with a high ceiling and no chance of derangement, a greater distance would be allowable.
>
> The whole idea is to so rigidly secure the wires that they cannot come in contact with each other or any other conductors, if loosened by shrinkage of timbers and floors or by careless knocking.

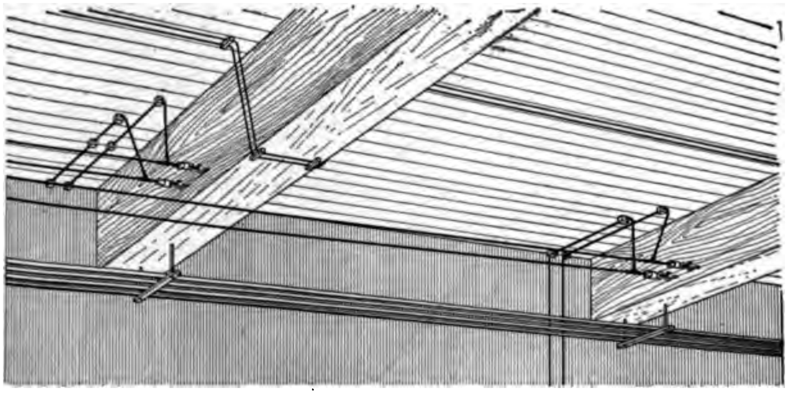

Fig. 88. Wiring on Ceiling Showing Use of Strain Insulators

Special methods must be followed at corners and in wiring over broken surfaces as on ceilings of mill-constructed buildings. Fig. 88 shows a use of "strain insulators" in making a turn on a ceiling. These are insulating balls having rings set in each side, the wire being looped through one ring and the hook on the beam through the other. Turnbuckles may be used to keep the wires taut. Ordinary cleats will not hold heavy wires at corners. With conductors of No. 8 B. & S. gauge or over, it is not necessary to "break around" beams but smaller wires should be carried around the beams as shown in Fig. 89. The cleats on the ceiling should be set off from the timbers 3 or 4 inches. If they are closer, the shrinkage of the timber or rough usage is liable to bring the wires into contact with the timber. On the other hand if the distance is greater, the wires are too much exposed to injury from brooms, ladders, and the like. With this arrangement any slack wire can be taken up by moving the cleats a little nearer the corner. Where beams are widely spaced some such method of support as that shown in Fig. 90 should be followed. Fig. 91 shows a less desirable method of support. In low ceiling rooms where wires are exposed to mechanical injury, wood guard strips (see Fig. 92) may be used to advantage. Where wires pass through partitions or walls they must be protected by tubes of porcelain or iron pipes lined with flexible tubing.

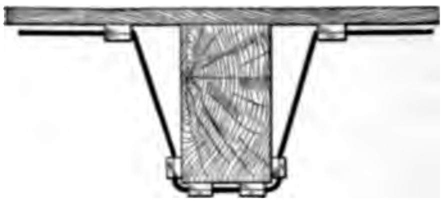

Fig. 89. Approved Method of Carrying Wires Around Beams

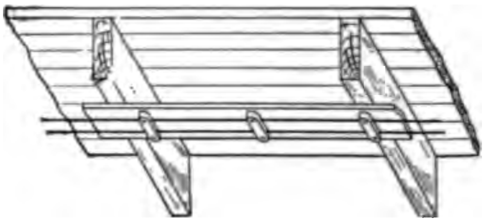

Fig. 90. Method of Running Wires between Widely-Spaced Girders

Wires on side walls must be protected from injury to a height of at least 5 feet from the floor either by wood boxing or by iron pipe as shown in Figs. 93 and 94. When iron pipe or conduit is used the insulation of each wire must be reinforced by flexible tubing extend-

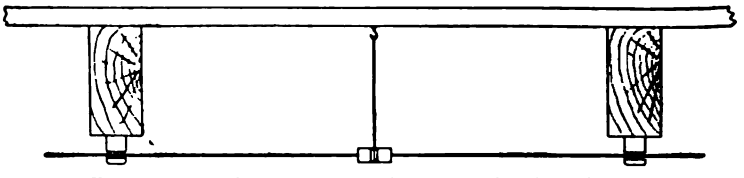

Fig. 91. Method of Avoiding Sag between Widely-Spaced Girders

ing from the insulator next below the pipe to the one next above it (see Fig. 93). For alternating current both wires of the circuit must be in the same pipe.

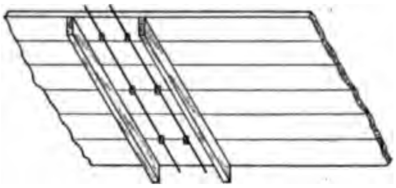

Fig. 92. Diagram Showing Use of Guard Strips

Open Wiring in Damp Places. The installation of electric wires in places exposed to dampness presents some peculiar difficulties requiring special methods. A film of water such as may be formed by steam or otherwise by condensation is a very fair conductor of electricity, and may reduce or even entirely destroy insulation which would be quite adequate in dry places. Acid or alkaline fumes or vapors are also good conductors in some cases and in addition they are liable to injure both the insulators and the copper of electric wires.

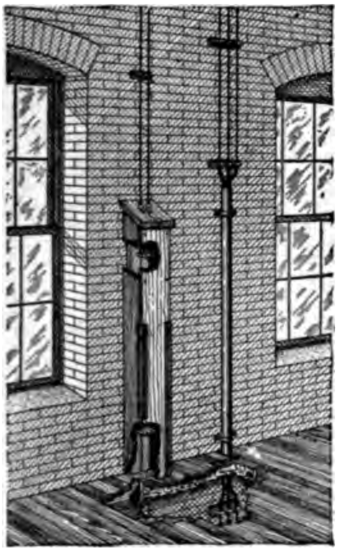

Fig. 93.* Wood Boxing as Protection for Wires on Side Walls

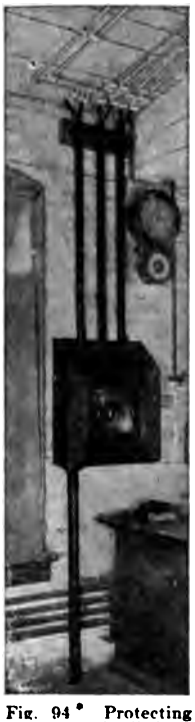

Fig. 94* Protecting Wires on Walls by Iron Piping

In paper mills, breweries, soap factories, packing houses, dye works, and cold storage rooms special pains must be taken to insure permanence and reliability of all electric fittings and appliances.

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*Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

The Code does not prescribe at length precautions to be taken in damp or otherwise exceptionally troublesome places, but merely specifies for open wiring that only rubber-covered wire be used and that the separation between wires shall be at least 2½ inches for voltages up to 300 volts (4 inches for higher voltages) and that all wires be kept *1 inch* from surface wired over instead of only ½ inch as in dry places.

There are two objections to the use of steel conduits in damp places, *first*, that all metal work is especially liable to corrosion even when well enameled or galvanized; and *second* and *more important*, that water is apt to collect in the pipes and gradually deteriorate the insulation. This water results from moisture condensed from the air during changes in the temperature and amount of water vapor present in the atmosphere. This condensation is often sufficient to be very troublesome and often leads to the adoption of open wiring of special forms rather than a complete conduit installation. Usually conduit is used in the more exposed or crowded places only and in such parts of the plant as are less liable to dampness.

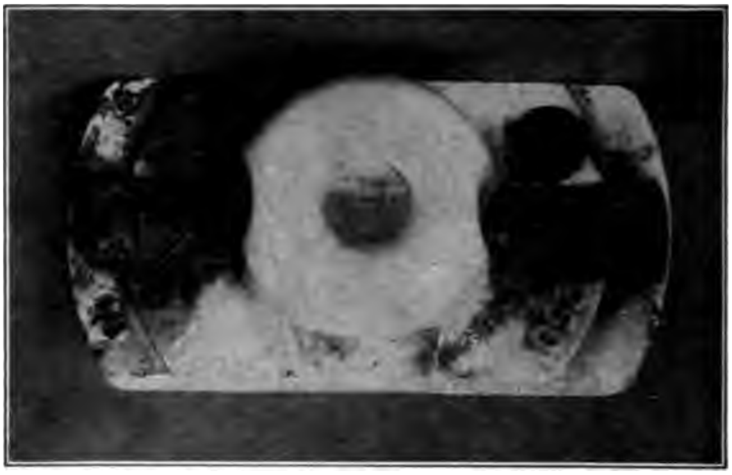


Fig. 95. Corroded Rosette Improperly Mounted on Damp Ceiling

In many breweries, packing houses, and other plants, walls and ceilings are continually dripping with water and in some factories fumes and vapors are present in large quantities at all times. A fairly good solution of the problem is possible where only water is to be guarded against, but where corrosive vapors exist, no thoroughly satisfactory method has been devised to resist indefinitely the corrosive actions. A good asphaltum paint will protect cabinets and conduits for a time and frequent repainting will extend the life of these parts of the equipment for a considerable period. It is evident that current-carrying metal parts should be enclosed in tight boxes wherever feasible and very frequent and thorough reinspections of the entire equipment should be made followed by renewals as faults develop. Fig. 95 shows the corrosion on a rosette improperly mounted.

In rooms where dampness is excessive the wires are sometimes run open in inverted wood troughs, one form of which is shown in Fig. 96 and in detail in Fig. 97. This trough serves to separate the wireway entirely from a wet ceiling and the sloping surfaces serve to carry the moisture away from the knobs on which the wires are held. The V-shaped blocks are spaced about 4½ feet apart and care is taken to make a close joint where the running boards come together at the top. The whole is thoroughly painted with an insulating paint. Fig. 98 shows open wiring on flat running boards for moderately damp places like basements or cellars.

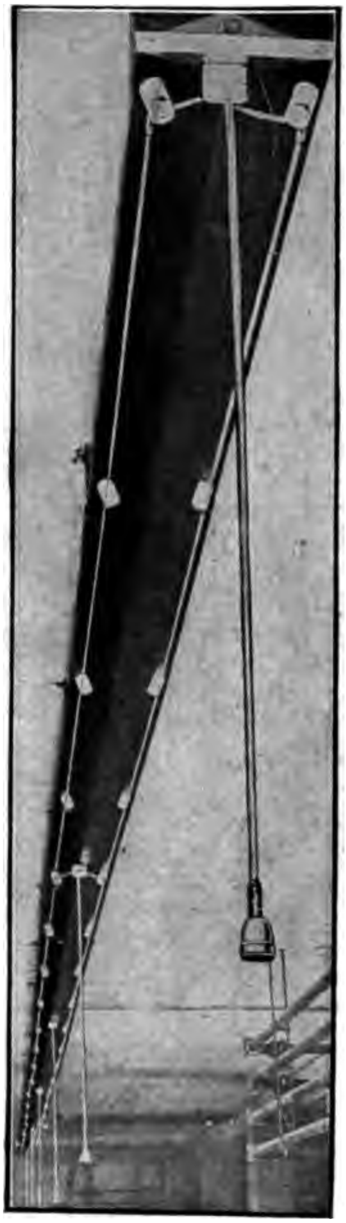


Fig. 96. Inverted Troughs on Damp Ceilings

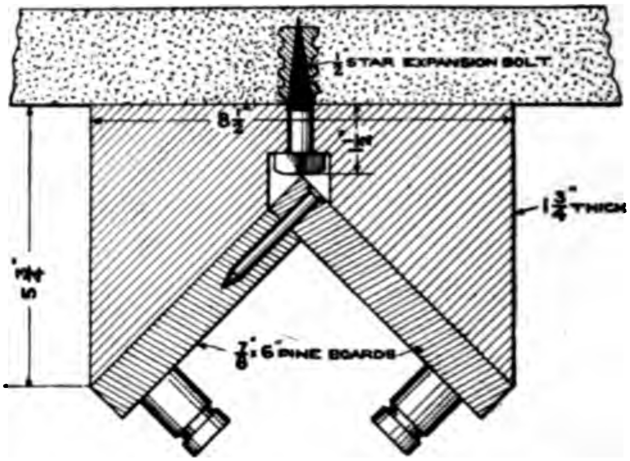


Fig. 97. Section of Wiring Trough

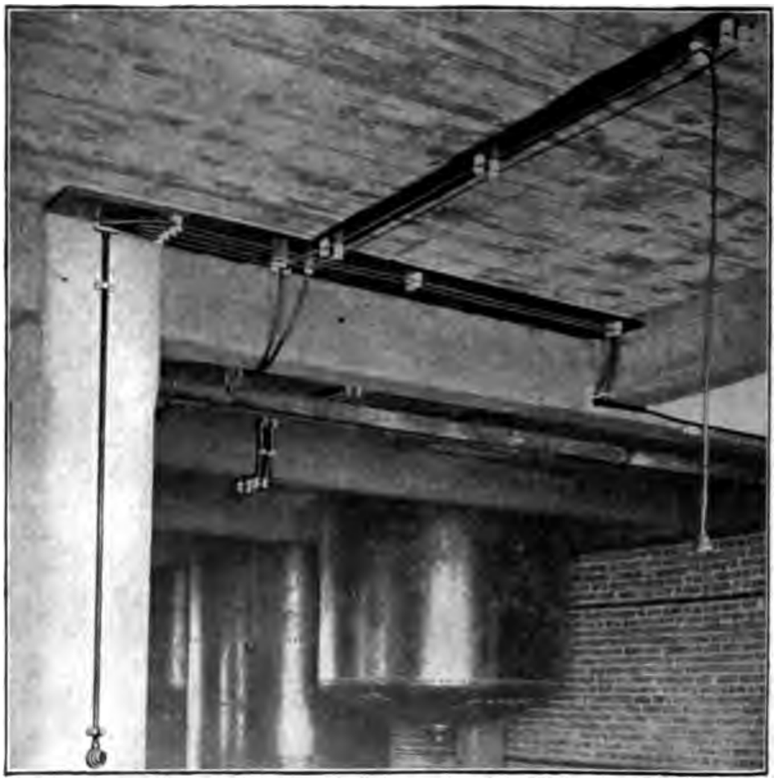


Fig. 98. Example of Wiring on Running Boards in Damp Place

All drop cords should be of extra heavy reinforced type or of standard rubber-covered wire and only weatherproof keyless sockets should be used with all wire joints soldered, taped and painted in the best manner. Motors and their resistance boxes or starters should be kept out of damp rooms if possible but if in such rooms, they should be installed with special reference to accessibility, cleanliness, and separation from wet floors or walls. Posts in middle spaces of rooms will generally afford better locations than side walls, which are always wet. Wood cabinets lined with slate or with stiff asbestos board are preferable in many wet places to metal enclosures if they are kept well painted inside and out with an asphalt or insulating paint. A single incandescent lamp in such cabinets if kept constantly burning will tend to keep the interior of the box dry, if the box is tight and if the door is kept closed. Such cabinets may well have a glass panel in the door to show the lamp and incidentally to mark the location when the room is dark.

Wires in Molding. *Wood Molding.* Wood molding is one of the commonest forms of protection for wiring and when properly used affords a cheap and fairly satisfactory installation. From one point of view it seems inconsistent to take every precaution in other forms of wiring to keep wires away from direct contact with wood surfaces, such as ceilings and walls and hidden spaces in frame partitions and floors, and on the other hand to permit them to be run in small grooves in strips of wood, as in molding work. The solution to this somewhat theoretical objection is found in the fact that in molding, the wires are completely enclosed in a wire-way especially designed for them, rather than allowing them to hang or be drawn over wood objects in a more or less accidental manner with no real protection, and a still better solution is to be found in the unquestionable fact that experience has proven the use of molding under proper conditions to be satisfactory.

Wood molding should *never* be used in concealed spaces or in damp places or for voltages over 300. The rule as to damp places precludes its use in cellars and basements, anywhere out-of-doors and generally on outside brick walls which are often more or less damp and likely to "sweat" and thus introduce moisture back of the molding. If the wood molding becomes soaked with water there is a liability of leakage of current from one conductor to the other or to "ground." If conductors in molding become overheated by excess current the wood may become charred, and charred wood is a fair conductor. The possibility of fire from such a cause is evident. Molding should be made of hard wood and should be thoroughly impregnated inside and out with a paint- or moisture-repellant. It must be made in two pieces, a backing containing the wire grooves, and a capping. The tongue between wires must be at least ½ inch thick and the wood under the grooves must be at least ⅜ inch thick. Figs. 99 and 100 give the forms of two- and three-wire moldings. Larger moldings are sometimes used for heavier wires but generally only small conductors are placed in wood moldings. Only good rubber-covered wire should be used and no joints or splices made in the wires in the molding, but where branch taps are necessary some form of fitting approved for the purpose should be employed. Such fittings as the one shown in Fig. 101 provide porcelain bases with suitable binding screws for the main and the branch wires and a cover over the joints.

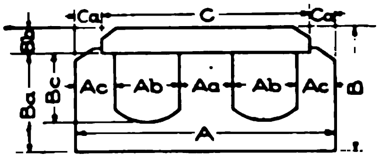


Fig. 99. Section of Two-Wire Molding

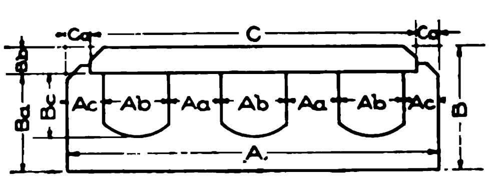


Fig. 100. Section of Three-Wire Molding

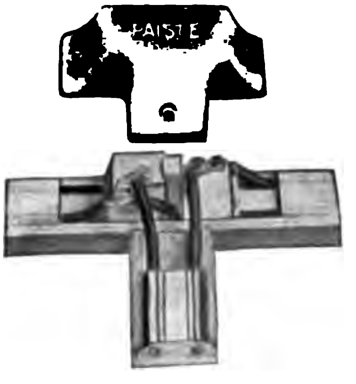


Fig. 101 Device for Making Tap in Molding

A large variety of receptacles (both for lamps and plug connectors), rosettes, etc., are available for use with wood molding and should be used instead of the ordinary patterns. Where it is desired to insert a snap switch, either a special switch approved for mounting directly on the molding, or else a sub-base of porcelain or hard wood on which the switch can be securely fastened should be employed.

Wood molding is often used in connection with other types of wiring and in such cases special attention should be given to making a good mechanical job where the conductors enter or leave the molding. Fig. 102 shows one form of protector for use in protecting wood molding at floor levels. The capping should be carefully and tightly nailed in place and under no circumstances should fixtures be attached to molding or any hooks or nails be driven into it for the support of lamp cords or other objects. The use of wood molding in show windows is undesirable: *first,* because of the dampness apt to exist there; and *second,* because in the process of decorating windows and arranging displays of merchandise nails will surely be driven into the molding with resultant injury to the insulation of the wires.

In conclusion, it may be said that wood-molding work is cheap and may be used properly, but is inferior to most types of wiring.

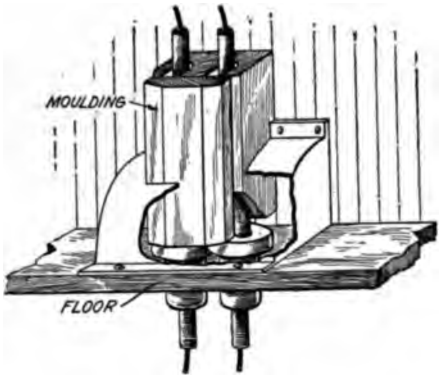


Fig. 102. Molding Protection at Floor Level

Metal Molding. Recently several types of *metal molding* have been introduced which are free from some of the objections adhering to wood molding, and make possible a neat, inexpensive, and convenient installation. In these moldings, as in those of wood, the wire is *laid in,* not drawn in as in conduits, and is covered by a metal capping. At present the underwriters' rules limit its use to circuits requiring not more than 660 watts of energy.

Special fittings are provided for angles, bends, taps, and crosses, and for switch, rosette, and receptacle bases. The molding can be bent for slight curves or offsets and when carefully installed gives good results. Fig. 103 shows such a molding and fittings.

Metal molding must be continuous from outlet to outlet and where it passes through floors it must be enclosed in an iron pipe for added protection. The backing must be secured by screws or bolts with heads countersunk so as not to obstruct the wire-way. Between lengths of molding and at all fittings and outlet boxes the joints must be mechanically and electrically secured. The fundamental idea is to secure an absolutely continuous metallic conductor throughout the entire run of molding and in addition the molding must be well grounded in a permanent manner. In this respect the molding is regarded in the same light as rigid metallic conduit. The reasons for requiring good electrical continuity and grounding will be explained later when the subject of conduit is considered.

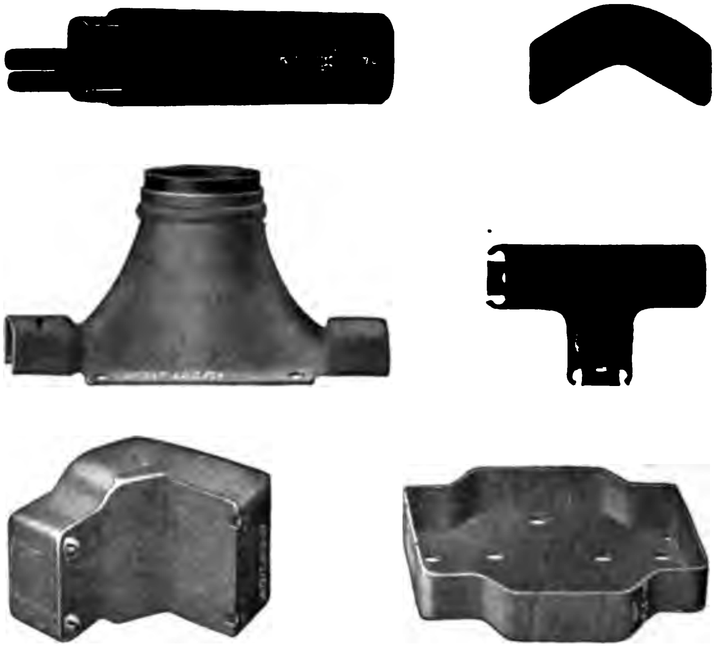


Fig. 103. Metal Molding and Fittings

Concealed Work. This kind of wiring is also often called "knob and tube" work since the wires are held on knobs and passed through tubes of porcelain. The great advantage of this method of wiring consists in the cheapness and ease with which a building, especially a frame building, can be wired. The greatest objection to the knob and tube work lies in the fact that the wires are wholly unprotected from mechanical injury and the building is not protected from the results of arcing between wires in case of a cross or short-circuit.

It is no doubt true that knob and tube wiring is the least reliable form of electric work and inferior to good conduit or armored cable. Where wires can be run open and are not exposed too much to mechanical injury, they are probably somewhat safer than when concealed on porcelain supports in walls, floors, and partitions. Open wiring is not possible in residences or where good appearance is a requisite, and the somewhat greater cost sometimes prevents the use of conduit. Therefore, recourse is made to concealed wiring and where an installation is carefully made a reasonably good result may be obtained. In many cities concealed work is entirely forbidden within "fire limits", that is, in the closely-built sections, but it is still very extensively employed in places where first cost and quickness of installation are the prime factors. Only good rubber-covered wire is allowable in concealed work.

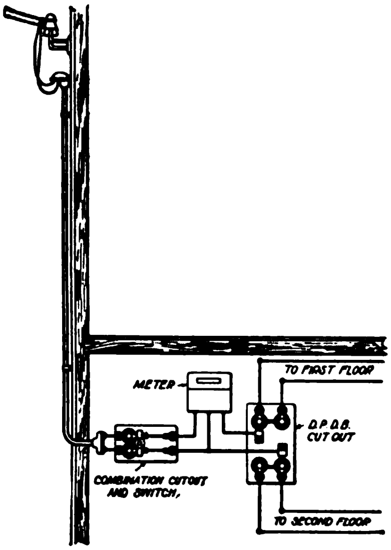


Fig. 104. Approved Wiring System on Entering Building

Approved Installation in a Residence. The wiring of a residence may be taken as an illustration of how the work should be done. The service wires are brought in through the wall near the ground preferably in iron conduit but allowably through bushings with drip loops outside, Fig. 104. As near as practicable to the point of entrance is placed the main service fuse and switch. These should be in a suitable cabinet though this is not obligatory. It should be understood that the wiring is placed during the erection of the building. In an ordinary frame building the wiring will be done just after the rough flooring and the partition studding has been placed, but before the lathing or any plastering is done. It should all be completed except the final connection of service wires, fixtures and fittings before any of it is enclosed or hidden, so that inspection may be made while all parts are accessible and visible.

From the service cabinet and meter as many circuits are run as may be required to feed the lamps and other devices to be connected, each being fused at the service center unless there is no change at that point in the size of wires. These circuits will pass up through the floor within porcelain tubes and will thence be carried on porcelain knobs fastened to the timbers and studding not more than 4½ feet apart. Where the wires pass through floor timbers, porcelain tubes, straight and smooth, must be used in holes bored in the wood and just large enough for the tubes. In general we may say that knobs are used where the wires run parallel with floor beams, and tubes where the wires are run at right angles to the beams. Fig. 105 shows the general method and Fig. 106 illustrates a two-piece knob of common type. These are preferable to one-piece knobs with which a tie-wire is necessary. The wires should preferably be run singly on separate timbers or studding, and must, except as noted below, be kept

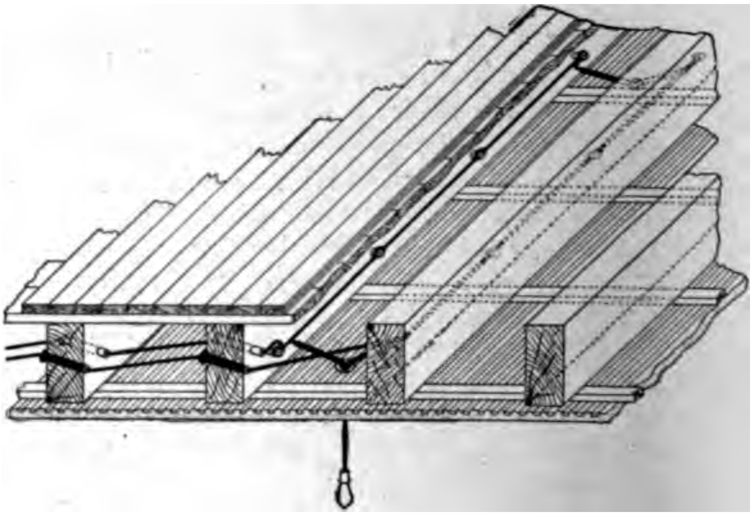


Fig. 105. Knob and Tube Wiring in Floor

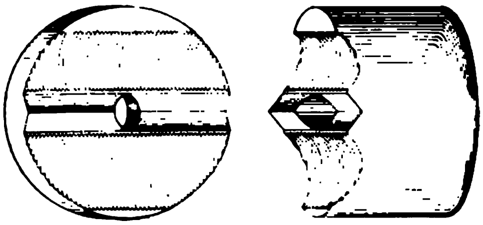


Fig. 106. Two-Piece Knob for Holding Wire

everywhere 5 inches apart. Fig. 107 shows clearly the use of the knobs and tubes, but the tubing shown on two of the upper wires

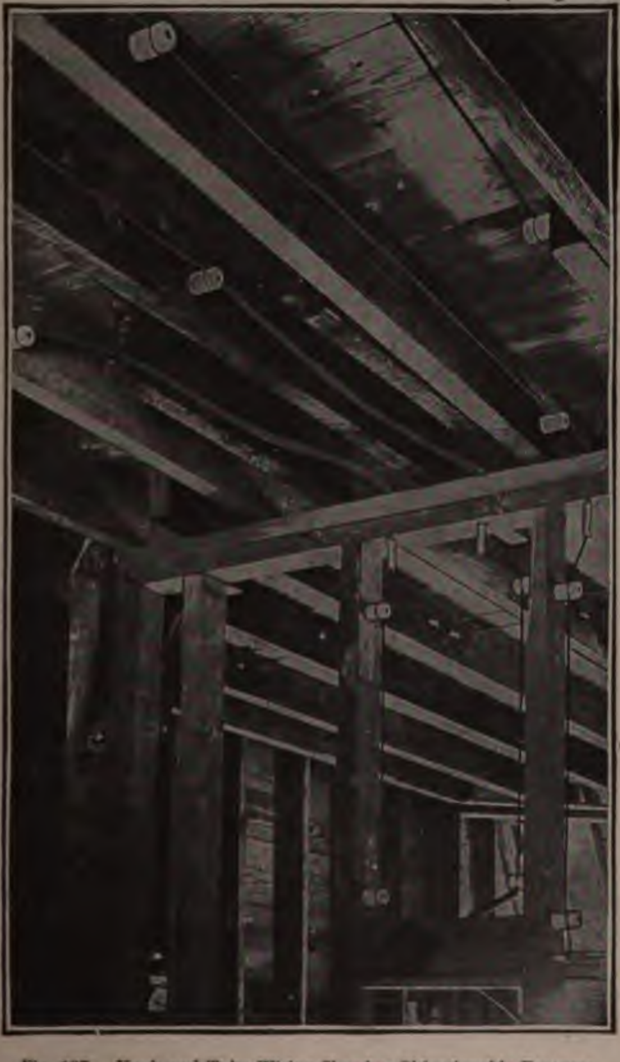


Fig. 107. Knob and Tube Wiring Showing Objectionable Features

s objectionable and knobs should have been used instead. It is ery desirable to use metal outlet boxes at *all* outlets and the added xpense of so doing is not large. Where flush switches or receptacles

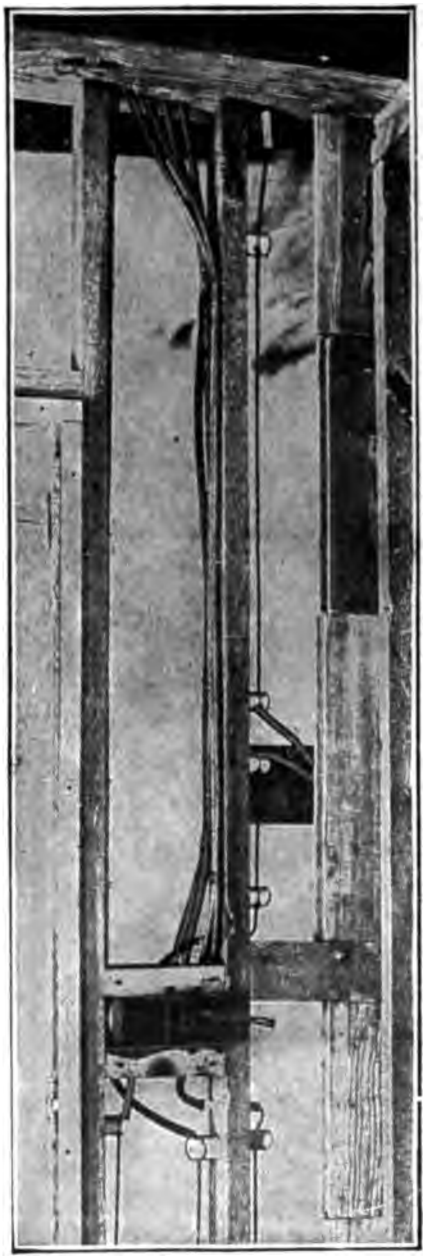


Fig. 108. Proper Use of Outlet Boxes

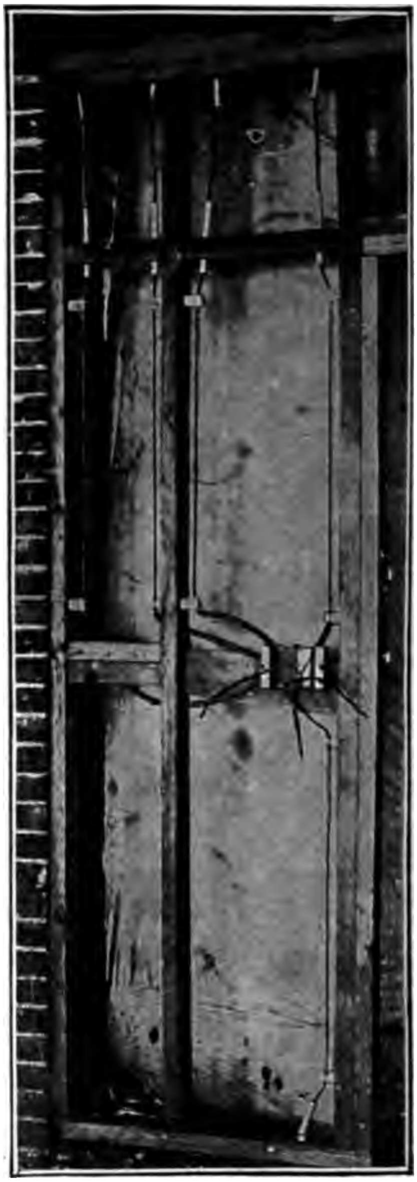


Fig. 109. Wiring in Partitions Showing Use of Porcelain Tubes

are used, metal boxes are absolutely necessary and in Fig. 108 several such boxes are shown as well as the method of mounting them on cross strips between the uprights. This illustration shows also an allowable use of flexible non-metallic tubing on wires in concealed work where it is impracticable to maintain the 5-inch separation.

Fig. 109 shows at the bottom the extra porcelain tube which should be put on each wire passing through timber at the bottom of a plastered wall to protect it from the droppings of wet plaster which will fall on it during the process of closing in the wall surface. This picture also shows very clearly the flexible tubing which must separately enclose each wire at every outlet, reaching from the last porcelain support into a switch box, or on ceiling or wall outlets, where no box is used, at least 1 inch beyond the surface. In the case of combination gas and electric fixtures the tube must extend at least flush with the outer end of the gas pipe as in Fig. 110.

When in a concealed knob and tube system, it is impracticable to place the whole of a circuit on non-combustible support of glass or porcelain, that portion of the circuit which cannot be so supported must be installed with *approved* metal conduit, or *approved* armored cable, except that if the difference of potential between the wires is not over 300 volts, and if the wires are not exposed to moisture, they may be fished if separately encased in *approved* flexible tubing, extending in continuous lengths from porcelain support to porcelain support, from porcelain support to outlet, or from outlet to outlet.

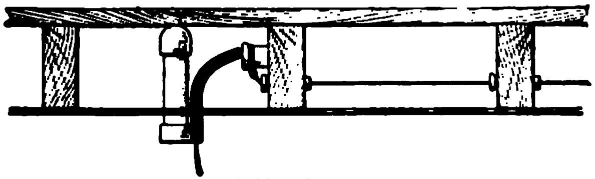


Fig. 110. Section Through Floor Showing Use of Tubing or Loom

There can, of course, be no assurance that such fished wires do not lie in close contact with gas or water pipes, or other wires, and so there is need of the protecting tubing.

In judging an installation of wires in concealed work, special attention should be paid to the wire joints. The rules allow these to be made in concealed spaces by means of soldered joints well covered with both rubber and friction tape. The wiring is usually on the so-called "tap plan," that is, taps or branches taken off wherever convenient. The necessity for good workmanship is evident as bad joints may easily set fire in dry floor and wall spaces. Fig. 111 shows such a defective joint which was found behind a lath-and-plaster partition. The joint was not taped and was hot when discovered. What is called the "loop-plan" is occasionally employed, all joints or taps being made at outlets where suitable boxes are

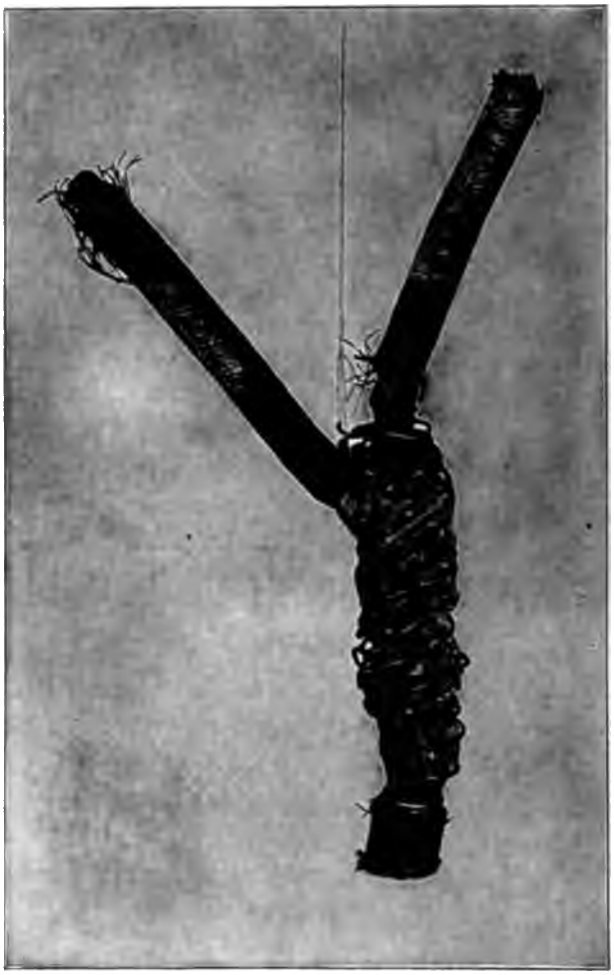


Fig. 111. Defective Joint Found in Actual Use

provided. This involves the use of more wire, makes the conditions at outlets more crowded, and is perhaps not as good for concealed work under the conditions usually obtainable. Either system is permitted by the rules.

Armored Cable. Armored cable for interior wiring consists of double-braided, rubber-insulated, twin wires, covered with a spiral steel strip armor which protects the conductors from injury and is at the same time flexible. It is largely used in wiring old buildings since it can be drawn into concealed spaces without fear of injuring the conductors. It is also used for new work and is in some ways easier and cheaper than rigid conduit. Fig. 112 shows a piece of twin-conductor house cable and some of the fittings for use with it.

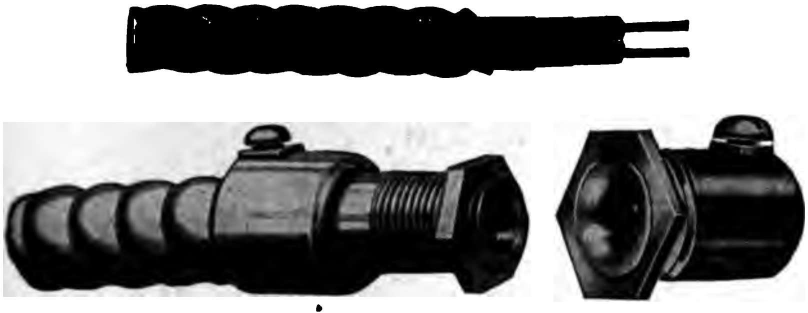


Fig. 112. Armored Cable and Fittings

With armored cable all joints must be made at outlets or in cabinets or junction boxes which are always accessible. No taps or joints are permissible except at such outlets or boxes. Great care should be taken to secure the armor very firmly to all outlet boxes in a way to give a good connection both electrically and mechanically, and the armor system must be permanently and reliably *grounded*. Where dampness may be expected there must be a lead sheath between the braided wires and the outer armor since the cable is not thoroughly moisture-proof.

Armored cable installations are superior to molding, open work, or concealed work, in that the wires are better protected. The fact that twin wire is used instead of separate conductors is at least a theoretical disadvantage, and the cable unless leaded is not absolutely waterproof.

The chief disadvantages of armored cable as compared with rigid conduit, consist in the somewhat greater difficulty of making good connections to the armor at outlets and still more in the impossibility of drawing out wires which have proved defective. However, for many places a thoroughly good job can be done with armored cable. Fig. 113 shows a characteristic piece of work of this sort.

Conduit Work. The earlier forms of conduit for interior wiring were made of paper or fiber and later of paper with a thin brass casing but these forms are now obsolete and entirely displaced by steel conduits made of either rigid pipe or flexible steel spirals. A limited use is still made of a form of conduit having a steel pipe lined with a heavy paper impregnated with some material to exclude moisture. This is, however, going out of use and almost all conduit work is now done with unlined pipe. Conduit, however, differs from ordinary commercial pipe such as is used for gas, water, or steam, in that it is carefully cleaned in the process of manufacture and then protected from rust both inside and outside by a good baked enamel or by some form of zinc coating. *Rigid conduit,* Fig. 114, gives a rather more workmanlike job than *flexible conduit,* Fig. 115, but the latter can be used in some places, especially in old buildings where

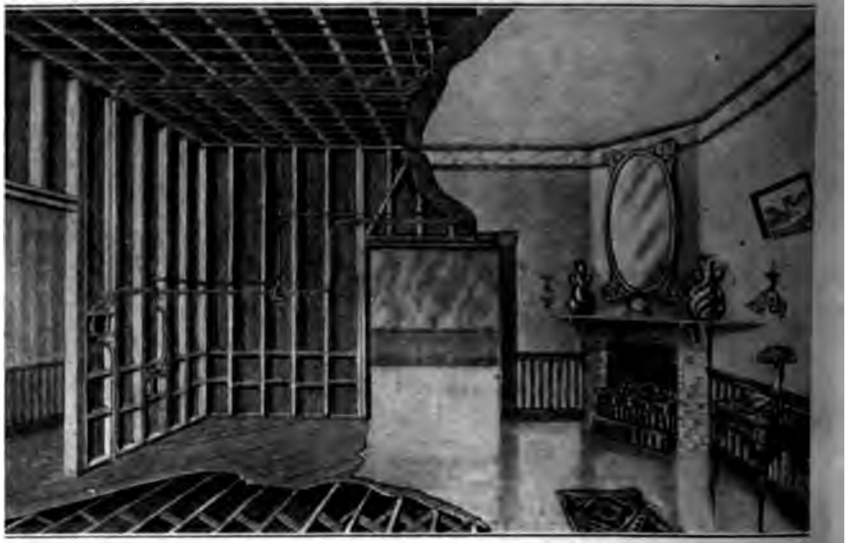
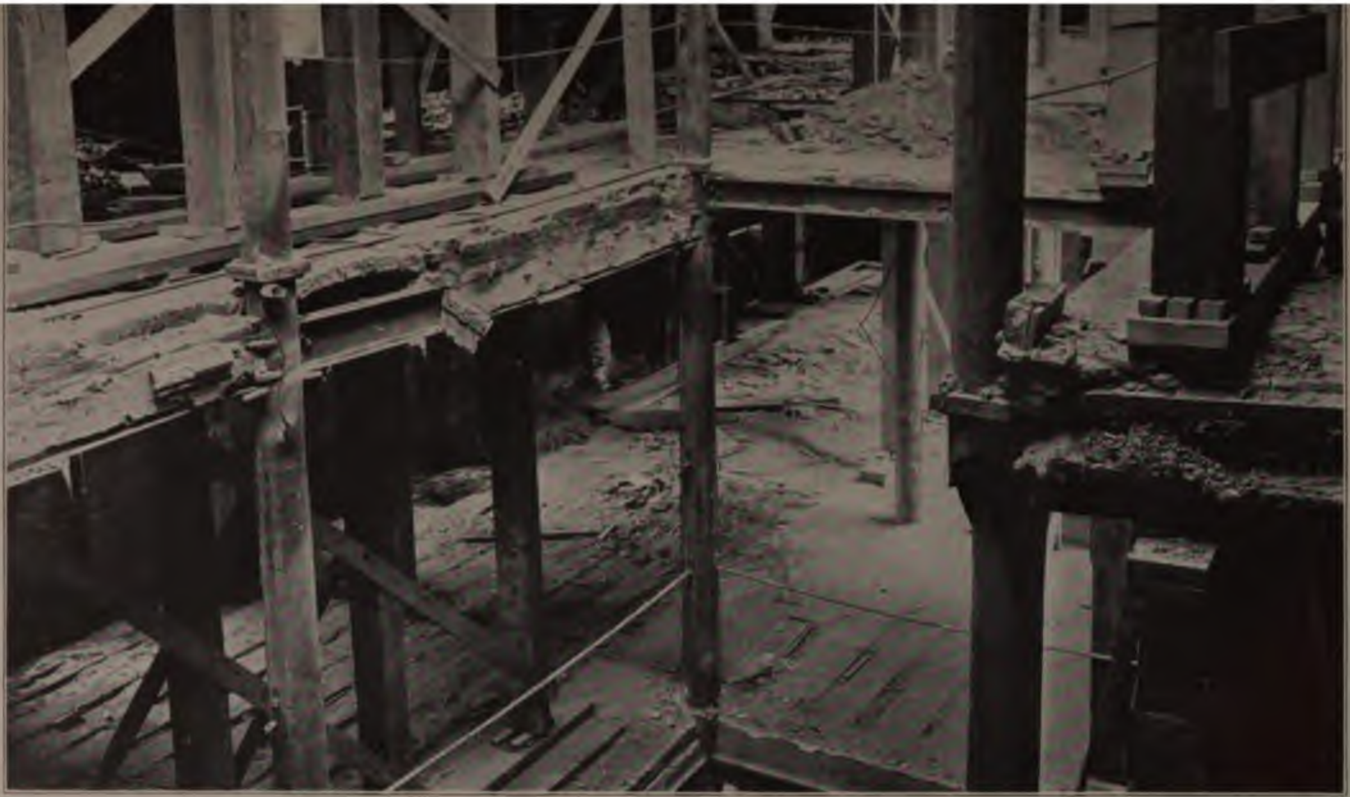


Fig 113. Wiring Showing Use of Armored Cable



GENERAL VIEW OF LIGHT SHAFT, EQUITABLE BUILDING

The Cast-Iron Columns on Each Side Are Shown Badly Fractured, the Metal Being from One-Eighth to One-Quarter Inch in Thickness at These Points.

Courtesy of New York Board of Fire Underwriters

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ASTOR, LENOX AND
TILDEN FOUNDATIONS

the use of rigid pipe would be impossible. If well fastened at all outlets and at all bends it affords a protection to wires second only to the rigid conduit. The complete protection afforded by conduit both of the wires from mechanical injury, and of the surrounding parts of the building from fire resulting from a burn-out of the wires, makes conduit work undoubtedly the safest form of electrical installation and one which is becoming more and more used, not only in the more expensive type of buildings but also in cheaper work as well.

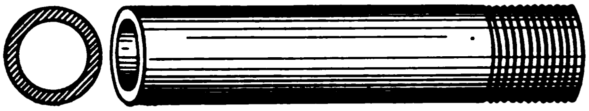

Fig. 114. Rigid Conduit

The essential principle of conduit work is to furnish a complete, strong and unbroken metal enclosure for conductors between outlets and to give to this metal-pipe system an electrical continuity and carrying capacity sufficient to serve as a safe path for any current which the failure of conductors within may impose upon it, for a time long enough to operate the fuses or circuit breakers protecting such conductors. It is also an essential characteristic of a correct conduit installation that all conductors can be *drawn in* after the entire conduit system is put into position and can at any subsequent time be *drawn out* in case any wire fails and must be replaced. These fundamental ideas will explain the reasons for most of the details prescribed in underwriters' rules for conduit work.

The construction details of steel conduit will be briefly discussed later and we consider here only methods of installing it.

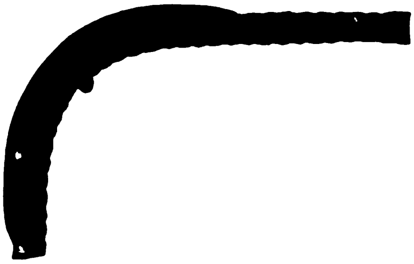

Fig. 115. Flexible Condui

There must be no breaks in the conduit system, that is, the pipe must be continuous from outlet to outlet or junction boxes. At every outlet metal boxes must be provided which the conduits must properly enter and to which they must be mechanically secured. This is usually accomplished by means of either threaded lock nuts on the pipe outside the box and threaded bushings on the pipe inside the box or by threading the conduit into tapped holes in the box. With flexible conduit a special approved clamp must be used for this purpose. Fig. 116 shows a box with a rigid conduit on one side and a flexible conduit on the other side together with a few of the fittings used in connection with it. No conduit having an internal diameter less than $\frac{5}{8}$ inch is allowable since this is as small as will permit wires of required minimum size to be drawn in without injury.

All elbows and bends in the piping must be so made that the conduit will not be injured and there should not be more than the equivalent of four quarter turns from outlet to outlet, not counting bends at the outlets themselves. If more turns are required, or wherever it would be difficult to draw in the wires, additional outlets called junction- or pull-boxes should be put in to facilitate the insertion of the wires. There should be no sharp edges, burrs or other obstructions either in conduits, at couplings between lengths, or at outlets, as they are apt to injure the wire coverings. Therefore, all ends of pipe should be reamed out before they are put into the pipe couplings or into boxes, and all bushings should have smoothly rounded edges.

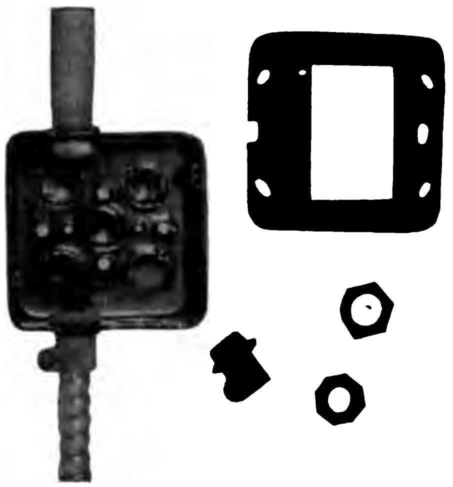

Fig. 116. Outlet Box with Connecting Conduit

The entire conduit system must be installed complete and, in fact, all the mechanical work on the building must be completed as far as possible, before any conductors are drawn into the conduits.

Pains must be taken to make all joints tight, so that there will be no bad electrical connections between parts of the metal system. It is not, of course, expected that under normal conditions the conduits will carry any current, but under some circumstances if the insulation of a wire fails, current may pass over the conduit. If the conduit is well grounded and all joints are well made a safe path to "ground" is afforded for a current large enough to blow the fuses protecting the circuit, thus cutting off the current before the pipe is overheated or burned through at the point where the bared wire has come into contact with it.

Conduits and gas pipes must be securely fastened in metal outlet boxes so as to secure good electrical connection. Where boxes used for centers of distribution do not afford good electrical connection, the conduits must be joined around them by suitable bond wires. Where sections of metal conduit are installed without being fastened to the metal structure of buildings or grounded metal piping, they must be bonded to a permanent and efficient ground connection.

It is rarely possible to perfectly insulate a conduit system throughout, and a positive ground is, therefore, required, so as to provide a definite path for leaking currents and thus prevent them from escaping through parts of a building, etc., where they might do harm.

The size of conduit which should be used for different sizes of wire or for different numbers of wires of specified size, depends upon the length of run between outlets where wires can be pulled or fed in, upon the number and the radius of bends and the thickness of the insulation on the wires. The rules, however, state that the same conduit must not contain more than four two-wire, or three three-wire circuits of the same system, except by special permission of the Inspection Department having jurisdiction, and must never contain circuits of different systems, that is, from different generators whether of the same voltage or not or whether both d. c. or a. c. or one of each.

In tall buildings special provision must be made to support the conductors in the vertical conduits to remove their weight from the connections, and the spacing of supports in such cases is prescribed as follows: No. 14 to 0 every 100 feet; No. 00 to 0000 every 80 feet; 0000 to 350,000 c. m. every 60 feet; 350,000 c. m. to 500,000 c. m. every 50 feet; 500,000 c. m. to 750,000 c. m. every 40 feet; 750,000 c. m. every 35 feet.

The following methods of supporting cables are recommended:

(1) A turn of 90 degrees in the conduit system will constitute a satisfactory support.

(2) Junction boxes may be inserted in the conduit system at the required intervals, in which insulating supports of *approved* type must be installed and secured in a satisfactory manner so as to withstand the weight of the conductors attached thereto, the boxes to be provided with proper covers.

(3) Cables may be supported in *approved* junction boxes on two or more insulating supports so placed that the conductors will be deflected at an angle of not less than 90 degrees, and carried a distance of not less than twice the diameter of the cable from its vertical position. Cables so suspended may be additionally secured to these insulators by tie wires.

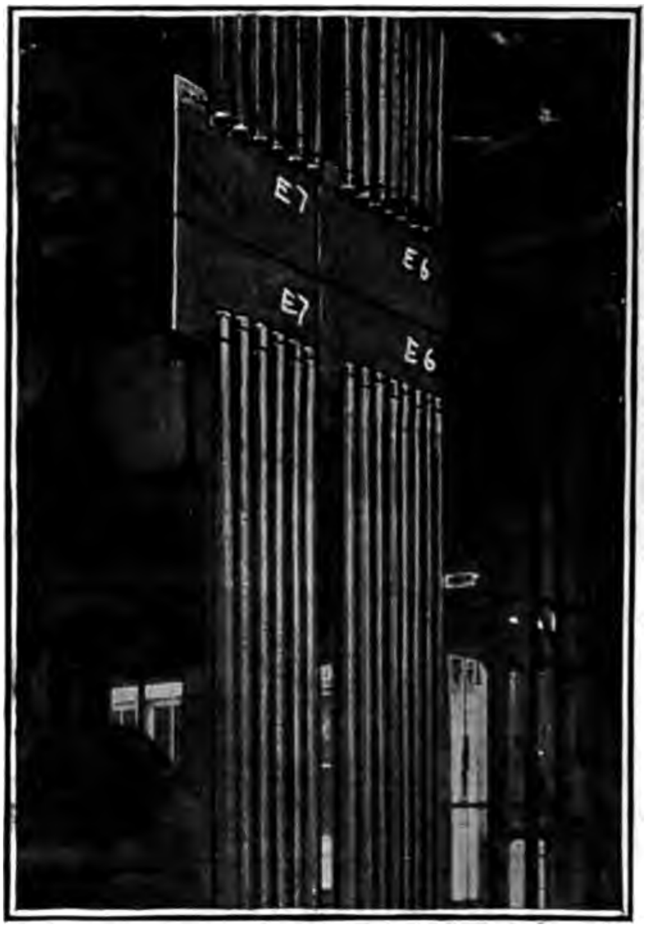

Fig. 117. Method of Supporting Conduit Risers

The second method is illustrated in Fig. 117 where a space has been left in conduit risers. The conductors will be held to the back plates by clamps and the whole will finally be enclosed in a heavy steel box which will form the connecting bond in the riser system. Fig. 118 shows one form of cable clamp used for this purpose.

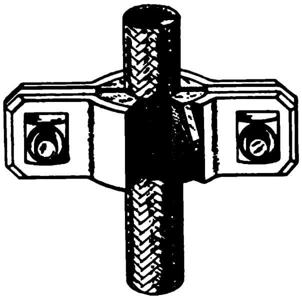

Fig. 118. Cable Clamp Used in Conduit System

Wires for conduit must be rubber-covered and have a double braid over the rubber. Twin wires are universally used for the smaller sizes, No. 14 to No. 10, and these have a braid over the rubber of each conductor and a second braid over both conductors together. For larger sizes single conductors, double braided, are used and for the largest sizes only one conductor is usually run in a pipe It should be noted, however, that for alternating-current systems the two or more wires of any one circuit must be drawn in the same pipe since otherwise there will be excessive heating of the metal pipes due to a magnetic action peculiar to alternating currents and known as "induction." Fig. 119 shows three large feeder ducts passing out of a steel service box. In this case the circuit was three-wire direct current.

The design of a conduit system of wiring for a large building may be a problem of some magnitude involving no little engineering skill and experience if the most economical, efficient, and sightly results are to be secured. A full exposition of the methods followed and the reasons for them does not fall within the scope of this book but the following general considerations are of some value in judging both the advantages of conduit work and the excellence of any given installation. In all conduit work it should be remembered that no taps or joints are permitted in conductors except at outlets, junction boxes, and cabinets, and that all these must be in accessible places. By accessible is meant accessible not only during the process of installation of the system but also after the building is completed and in use. A junction box is not "accessible" if it is necessary in order to get at it, to take up portions of floors or make openings in ceilings or side walls. This prime requisite of conduit work makes it necessary to run all conductors on the "loop" plan which means that all lines, branches, and control circuits (as to switches) will consist of a pair of wires starting at the same point at some outlet box or cabinet and running generally in the same pipe to some other outlet where the socket, switch, or other device is placed. Conduit systems may be made with the piping concealed or exposed as may be dictated by the character of the building and the finish desired.

In frame buildings where the electric installation is put in during the original construction the conduits are placed after the main framing and partitions are in position and will be arranged to pass through walls and floors with the outlet boxes and cabinets set and fastened securely at or very near the places where they will be when the building is done. In laying out such work little regard need be paid to having pipes run straight or parallel to each other so long as they are so shaped at bends and otherwise disposed as to make it easy to draw in the wires. The chief considerations are the position of outlets, the proper pipe sizes for the wires, and the proper subdivision to secure correct fusing of incandescent lamp circuits according to the rule which permits not over 660 watts on any such circuit.

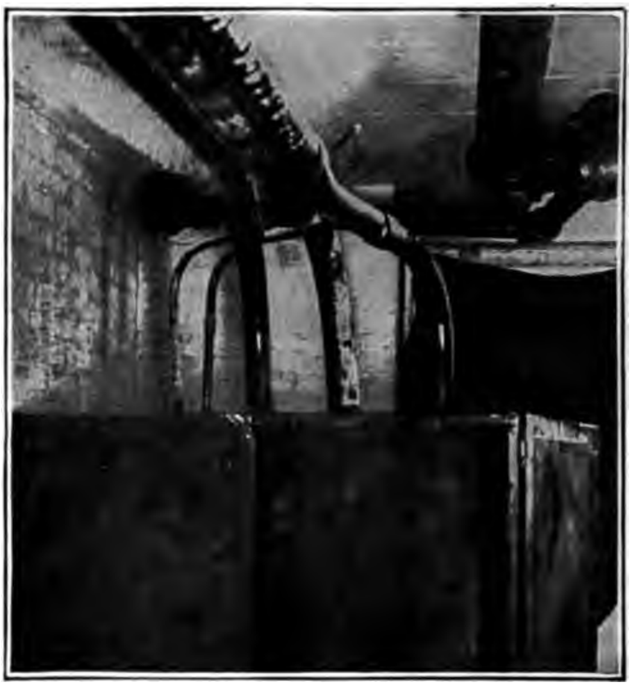

Fig. 119. Steel Service Box and Feeder Pipes

Characteristic Conduit Installation. Fig. 120 shows a characteristic layout for conduits and outlets for a small apartment.

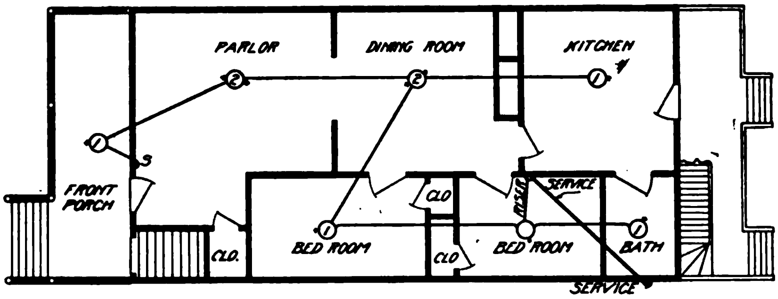

Fig. 120. Characteristic Layout for Conduits and Outlets in Small Apartment

At the point marked "riser" a main conduit rises from the "service" in the basement and on each floor has a cabinet where the supply wires for that floor are taken off and fused and where the meter may be installed. In laying out such a system of conduits or in inspecting it one should start from the service entrance cabinets from which the conduits should enter. If this cabinet contains not only the service fuses but also the sub-fuses of the branches, the several circuits should be examined to see that they are properly fused, and that they are distributed in pipes of adequate size. The several runs of conduit should then be followed throughout their entire length to see that all couplings between pipes and all attachments to outlet boxes are thoroughly tight and that both conduits and boxes are

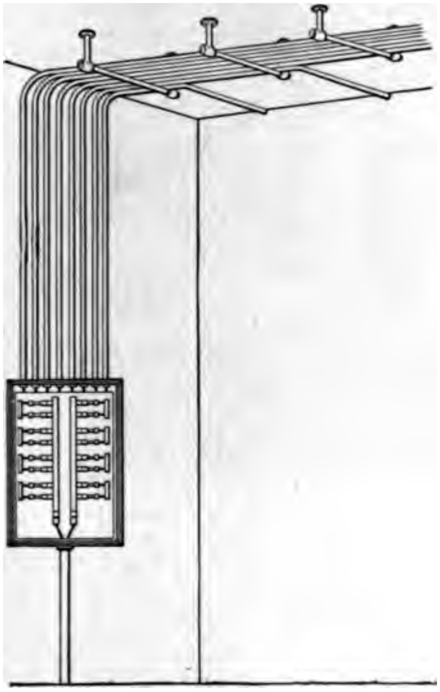

Fig. 121. Approved Ceiling Support for Conduits

fastened by straps or screws so that no strain will be put upon the screwed joints. Care should be taken to see that there are no sharp bends anywhere and that no more outlets are set in one circuit than is proper and that all are accessible. Observe whether due provision has been made for installing fuses wherever there will be a change in the size of wire. It is often cheaper and more satisfactory to continue a somewhat larger wire than is required, than to change to a smaller size and insert fuses. In no case should fuses be installed in small outlet boxes, but only in junction boxes or cabinets of ample size.

After the wires have been drawn in, observe whether it is possible to trace a given pair from outlet to outlet and if there is doubt on any point it may be necessary to demand that certain wires be drawn out for inspection. There should, of course, be absolutely no corners, Y-shaped fittings, or other devices in any place which will prevent any or all wires from being taken out and replaced at any time even after the building is completed. It is well to observe whether there are bends or traps in the piping in which water resulting from condensation or otherwise can collect. All conduit should be practically uninjured by the work done on it, all pipe ends should be threaded and reamed and the entire metal system should be firmly supported and secured so as to be free from vibration or rattle. The system must be electrically continuous throughout and must be permanently and effectively grounded.

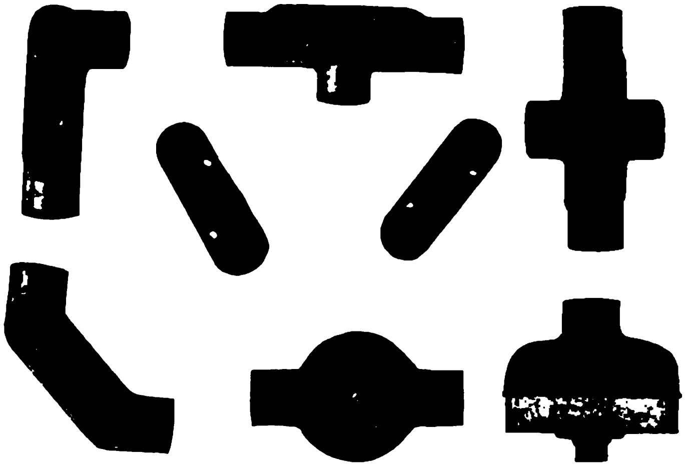

Fig. 122. Fittings Used for Exposed Conduit Work

Where conduits are run exposed, more attention should be paid › appearances. All runs should be in straight lines parallel to walls f the rooms and arranged in a symmetrical and orderly manner. maller sizes of conduit can usually be fastened to ceilings or walls y ordinary pipe straps, but where large conduit is used some form f pipe hanger is required and there are special patterns of a variety

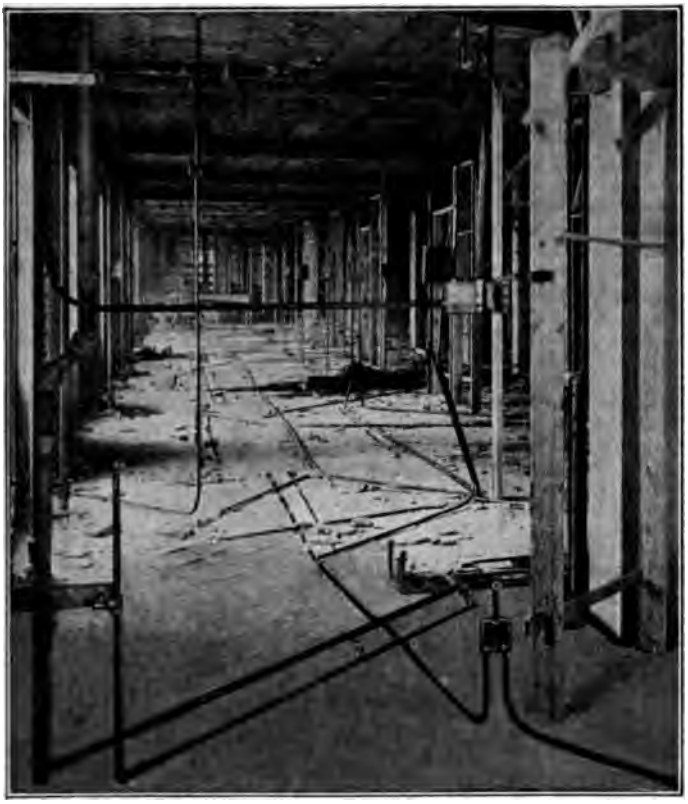

Fig. 123. Conduit Wiring Circuits Laid before Partitions and Floors are Completed

f designs. Where a number of conduits are run parallel the form f supports shown in Fig. 121 is excellent. With exposed conduit a ariety of fittings can be used for outlets, junction boxes, and the ke, which add much to the neat appearance and also provide for ›ints and traps as well as for mounting sockets, switches, and other nall devices. Fig. 122 shows a few such fittings for exposed conduit.

These are made with threaded nipples into which the conduit may be screwed and when so used these fittings need not be fastened to the wall or ceiling in any way, but are considered to be firmly enough held by the pipe itself. However, if boxes requiring lock nuts and screw bushings on pipes are employed they must be separately secured to the surface of wall or ceiling by screws and all cabinets of any size whatever should be so fastened. Exposed conduit work is usually employed in factories, warehouses and elsewhere if the finish of room does not require all piping to be out of sight.

Some special problems arise in conduit work in fireproof buildings. In these types of structure the conduit work is done after the rough floor work is completed, the conduits being usually laid on the tile floors so as to be covered by the top finish of cement usually laid over the tiling. Fig. 123 shows such an installation and it will be noted that the baseboard and all side-wall outlets have been placed, before the tile partitions between the rooms, have been set. In a fireproof building it will generally be necessary to run the main risers before the floors are made and to arrange for the distributing cabinets on each floor. Fig. 124 shows a cabinet in place in the unfinished partition with two conduit risers entering it from below and the branch circuits going out from the top to various parts of the building. The cabinet in this case has been fastened by rods above and below.

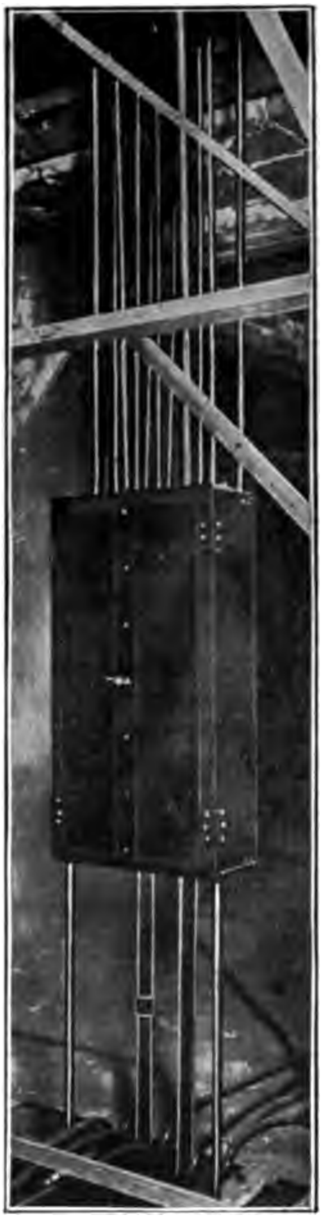

Fig. 124 Wire Distributing Cabinet

In concrete buildings it is often somewhat difficult to place the conduits and the boxes so as to clear the reinforcing material and at the same time keep the metal parts well covered at all points. Special methods have to be adopted varying with the type of concrete construction employed but in all cases an effort should be made to secure proper draining of conduits. The water from the concrete is very liable to get into the conduit system at the outlets or elsewhere, and when once this occurs it is difficult to get it out. Its presence is, however, most objectionable as it tends to injure the piping by rusting and also to deteriorate seriously the insulation coverings on the wires. This is a difficulty which should be considered in locating outlets in such a building and which requires very great care to entirely overcome. It is a matter of some difficulty at times

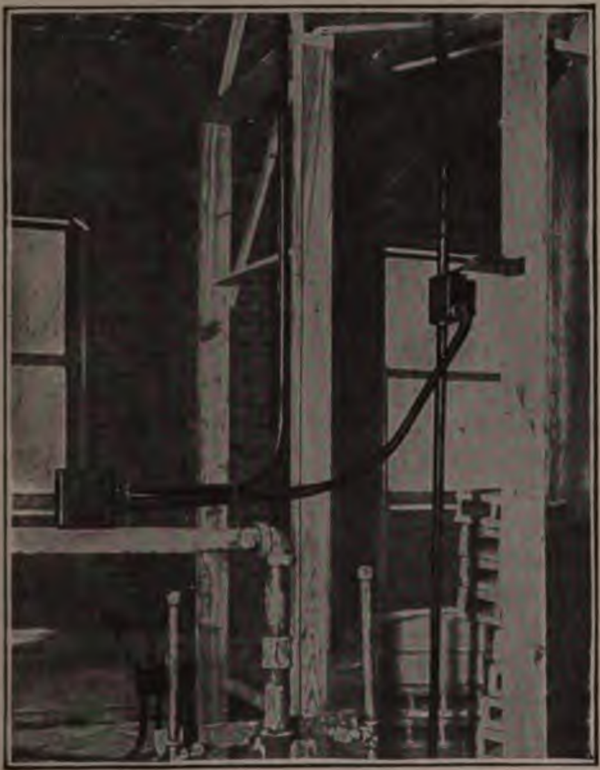

Fig. 125. Method of Placing Outlet Boxes in Tile Partitions

to secure outlet boxes on the concrete forms or in correct position where tile is to be used so as to be sure that they will be in the right position and firmly held when the building is completed. Ceiling boxes should be held by special hangers from each box up into the tile or concrete and reliance should not be placed on the conduits alone to hold them. Boxes set where tile partitions are to be subsequently erected should preferably be held by iron straps to adjacent steel work wherever this is practicable. Fig. 125 shows how this may be done.

SPECIAL INSTALLATIONS

DECORATIVE AND COMMERCIAL LIGHTING

Decorative Lighting. Decorative lighting by means of incandescent lamps is often desired either inside or outside buildings. The chief hazards of such work lie in the use of inferior materials hastily put together and poorly located and fused. The voltage should never exceed 150 volts in such work and not more than 1,320 watts of energy should ever be allowed to be dependent for protection upon a single cut-out. It is highly improper to take current for such systems from ordinary outlets which are wired for only small currents, since by so doing the wires to the outlets will be overloaded and the proper fuses for the wires will have to be replaced by others of too great capacity to furnish safe protection. The supply should be taken only from points on the circuit (as at distribution boards or panels) where the correct fusing and wiring can be provided for.

There is obviously no real distinction between *decorative* lighting and *ordinary* lighting arrangements except that the former is usually put up for temporary use only. If these temporary circuits are installed in a workmanlike manner and if good wire and good sockets are used there need be no special hazard provided the wires are not tacked up in a manner liable to injure the insulations and are not made to serve as supports for inflammable decorations of cloth or paper. Festoons of keyless weatherproof sockets well connected to standard rubber-covered wire (not flexible cord), and kept separated from all combustible stuff, do not present any great hazard but no such installation should be made without great care and should never be allowed to remain as a permanent installation unless it is fully protected and made the equivalent of standard work in every respect. The use of extra "carrier" wires for such festoons is very desirable as they remove all strain from the current-carrying wires and connections. Show windows are very frequently decorated by temporary electric displays of all sorts especially during the holiday season and such window displays are very often wired in utter disregard of all safe rules. The wires are often made to serve as supports for merchandise of very inflammable material, and where tinsel, cotton batting, and similar materials are employed, the conditions are excellent for a rapidly-spreading fire if any electric failure should occur. Incandescent lamps are often allowed to lie against inflammable materials and small motor-operated advertising or other novelties may contribute their share to the danger. The fact that an installation of this sort is "temporary" does not lessen the hazard so long as it is in operation and should not in any sense be considered as an excuse for allowing practices which are known to be dangerous. Property owners are often ignorant of the extent to which ill-advised temporary decorations jeopardize their buildings.

In show-window lighting, the lamps, whether temporary or permanent, should be placed either in the front or the top of the window, proper reflectors being used to throw the light upon the goods displayed. This plan almost invariably gives better results in lighting than lamps placed in sight, and scattered through the window and among the goods, and is also very much safer.

Outline Lighting. A very common form of decorative work consists of what is known as *outline lighting.* In this class of work rows of incandescent lamps are used on the exterior of buildings to outline the chief architectural features, to mark entrances, etc. Lamps and wiring used for such purposes inside buildings come under the regular rules for inside work but outside outline lighting may have some special characteristics. Only low potential circuits (under 550 volts) should be used and the wiring either open work or in conduit. Molding, either wood or metal, is not allowable since it does not afford protection against moisture. In open work the same spacing of wires from the surface (1 inch) and from each other (2½ inches) must be maintained as in all exposed wiring in damp places. If the use of flexible tubing is necessary, as at crosses or where regular spacing cannot be maintained, the ends of the tubing must be sealed and painted so as to exclude moisture, and for a similar reason armored cable, if used, must be of the type having a lead sheath over the conductors and under the armor.

In order to assure proper control and fusing of outline-wiring circuits they should have their own separate switch and fuses enclosed in a suitable metal cabinet which must be watertight if placed out-of-doors. Small candle-power lamps (2 to 4) are almost always used for outline wiring and may be so grouped on the circuits that not more than 1,320 watts will be dependent on a single pair of fuses but in no case should more than 66 sockets or receptacles be connected to a single circuit. This limitation of the number of lamps is to prevent any trouble in a single socket causing too much arcing or burning before the fuse protecting its circuit will open. All the sockets and receptacles in outline wiring must be of the keyless porcelain type and the wires connecting them must be soldered to the lugs. With conduit work in outline wiring special attention should be given to making the entire system as water tight as possible. The receptacles set in the covers of steel outlet boxes or *conduits* should be provided with rubber gaskets, and similar rubber rings may also be used to advantage about the bases of the lamps to prevent the entrance of water into the receptacles themselves.

Electric Signs. An endless variety of electric signs are shown on the streets of cities and towns today, from the simplest illuminated panels to huge structures containing many hundreds of lamps and operated by very complicated "flashing" machines. An elaborate treatment of all types of signs cannot be given here. The large signs erected on roofs should come under the supervision of the building department of a city or under both electric and building departments. Many of these signs are hazardous because of the obstruction they offer to firemen, the large amount of power they use, and the inadequate provision made for cutting off current from them either automatically or by hand switches in accessible places. No combustible material should be permitted either in or near such signs. It is preferable that all wiring be in conduit but where this is impracticable, the supports and spacing of wires should be excellent and the sides of the circuits should be kept apart preferably by bunching all wires of one polarity into cables covered by waterproof and slow-burning jackets. The mass of inflammable rubber-covered and braided wire necessary for a large sign requires skilful arrangement to avoid a serious blaze in case of failure.

Signs of every size should be "all metal," sheet steel being not less than No. 28 U. S. gauge and frames being in all cases of ample stiffness and strength. Metal parts should be well protected by paint or enamel and the sign structure should be reasonably water tight but have drainage holes in the bottom to let out any water that may collect inside. The wires should be soldered to all receptacle terminals, should be only rubber-covered and should be brought out through the sign structure either in conduit or in well spaced porcelain bushings with drip loops. In supporting the sign attention should be paid to preventing wear or abrasion of the leading-in wires by swinging of the sign. Many cities have especially elaborate rules for the placing and supporting of signs designed to reduce the possibility of their falling or of their interfering too much with the use of fire-escapes or the work of firemen in case of fire in the building.

Sign Flashers. The flashing, and other very elaborate effects of electric signs, are accomplished by the use of what is known as sign-machines or flashers, Fig. 126, which consist essentially of motor-driven drum switches often of great size and complexity. These machines are hazardous chiefly from their use of many necessarily rather frail single-pole brush switches with large numbers of connecting wires leading to them and from the fact that being essentially automatic, such machines are liable to be neglected and poorly maintained. The location of a sign machine should be such as to remove it from the chance of accidental injury or tampering, to permit the direct and well arranged running of circuits to it, and to render it accessible for cleaning, adjusting, and inspecting at all times. A flasher should never be installed in a closet or other concealed space. If it is impracticable to mount it outside the building near the sign, as is preferable, a location should be chosen that

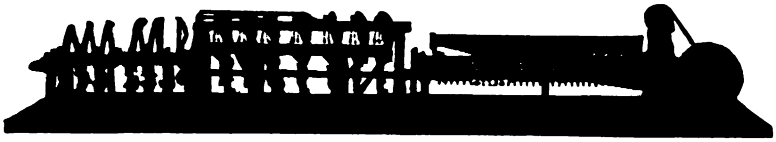

Fig. 126. Sign Flasher for Displaying Electric Signs

will reduce as far as possible the amount of wiring required. A platform or shelf over a doorway and just inside the building is often the best place available. A heavy metal cover must be provided but this should be removable so as to permit adjustment of all operating parts within.

THEATER WIRING

General Specifications. The electric equipment of theaters is of great importance both because of the large value of these properties and also because of the life hazard involved in any public building in which large numbers of people assemble. The electric equipment of a modern theater of the first class is generally very elaborate, involving as it does not only the brilliant illumination of large rooms, the stage, and many smaller apartments, but also the power equipment for handling curtains, scenery, and other paraphernalia and the numerous devices of special character for producing stage effects. In the meaning of the Code a theater is defined as a building or part of a building in which it is designed to make a presentation of dramatic, operatic or other performances or shows for the entertainment of spectators, which is capable of seating at least 400 persons, and which has a stage for such performances that can be used for scenery and other appliances. All theater wiring not specifically covered by special rules should conform to standard rules and requirements for work of its class. The special rules naturally divide into those which concern the protection of life chiefly and those which concern primarily the fire hazard, though, of course, the latter have a direct bearing on the life hazard also, since even a relatively small fire in a theater may produce a panic resulting in injury to many persons.

For the purpose of insuring the most reliable maintenance of proper lighting and consequent safety and freedom from panic in the audience, the underwriters' rules suggest that where the source of electric supply is outside the building there must be at least two separate and distinct services where practicable, fed from separate street mains, one service to be of sufficient capacity to supply current for the entire equipment of the theater, while the other service must be at least of sufficient capacity to supply current for all emergency lights. By "emergency lights" are meant exit lights and all lights in lobbies, stairways, corridors, and other portions of

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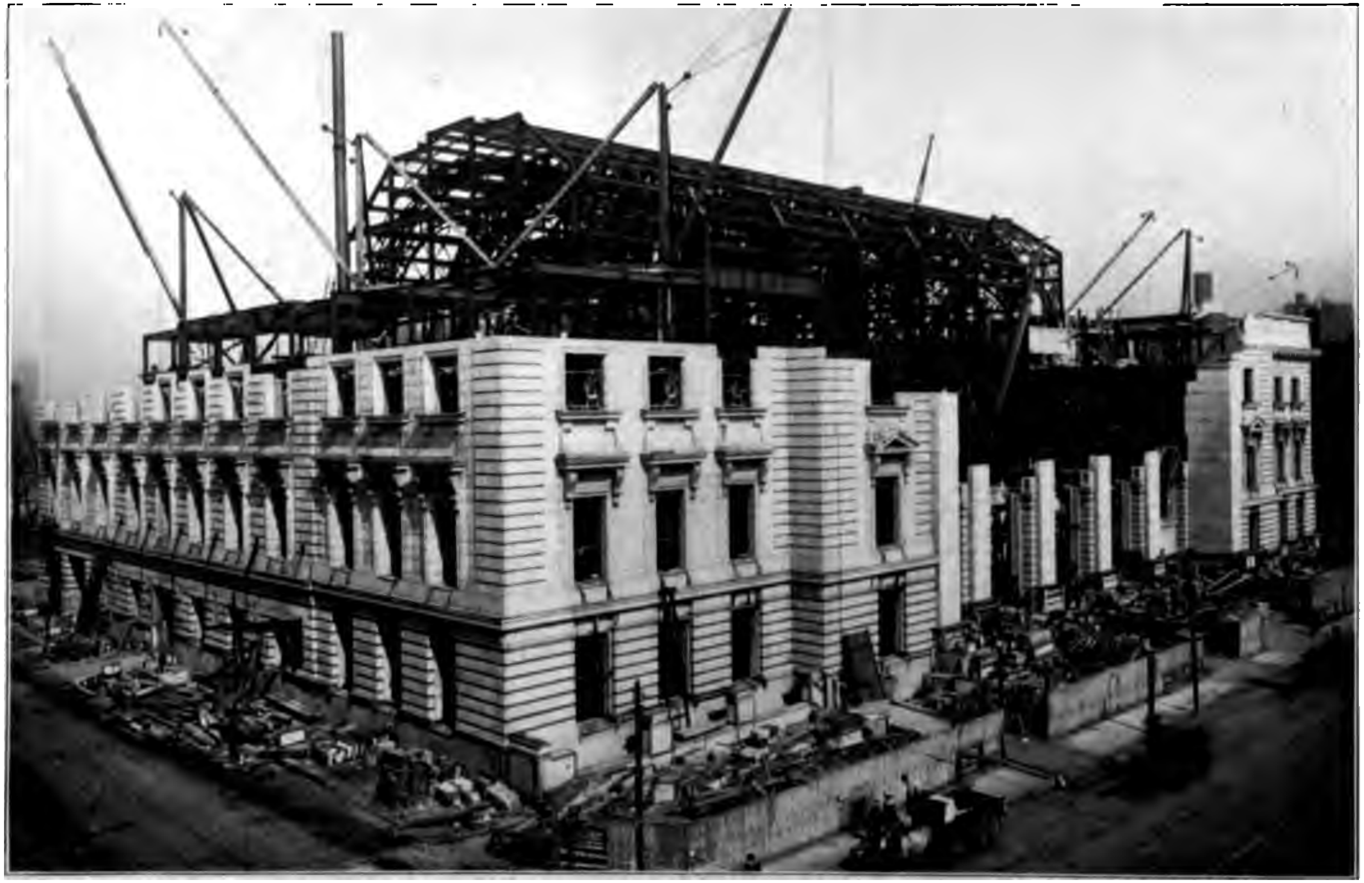

CHICAGO AND NORTHWESTERN RAILWAY DEPOT IN PROCESS OF CONSTRUCTION
Fine Example of Fireproof Construction of Stone, Protected Steel, and Concrete.
Architect, Chas. S. Frost, Chicago. General Contractors, Geo. A. Fuller, Co.

the theater to which the public have access which are kept normally lighted during the performance. Where source of supply is an isolated plant within the same building, an auxiliary service of at least sufficient capacity to supply all emergency lights must be installed from some outside source, or a suitable storage battery within the premises may be considered the equivalent of such service.

The principal hazards in a theater result from the stage equipment since it is there rather than in the auditorium that large currents are used; many conductors are required, and all sorts of special devices are employed often in close proximity to combustible material such as scenery. Furthermore, the constant changes, additions and special requirements for different productions result in subjecting the electric equipment to exceptionally hard wear and tear on theater stages so that proper upkeep can be secured only by the use of the most approved materials and methods and constant re-inspections. All permanent electric work on the stage side of the proscenium arch must be in conduit or armored cable except in border lights and on the stage switchboards.

All of the stage circuits, footlights, borders, arc lamps, and usually all house lighting are controlled from a switchboard located on the stage at one side of the proscenium arch. This results in a very large number of cables and wires being concentrated at this board and calls for very careful planning if anything like safe and orderly arrangement is to be secured. The space available is often small and circuits are, therefore, liable to be unduly crowded and confused. The design of a large stage switchboard calls for no little engineering skill, which is too often noticeable chiefly from its entire absence especially in older houses. The space back of the board should be of ample size, readily accessible but entirely enclosed by absolutely fireproof walls and doors and preferably directly ventilated to the outside by a special brick chimney or large flue. All circuits should be controlled by substantial knife switches and fused by standard enclosed cut-outs in accessible places where their operation will not in any way be liable to set fire to the wire insulations. It is very desirable that all wires on the back of the board be covered with asbestos jackets and be well spaced.

Dimmers. The *dimmers* or special rheostats for gradually reducing the intensity of incandescent lamps either in the auditorium or on the stage constitute often a very large installation of heat-developing apparatus which should be carefully located on iron brackets or on open galleries absolutely separated from any possible contact with burnable stuff. Fig. 127 shows a bank of dimmers.

Footlights and Borders. Among the more important fixed-appliances are the *footlights, border and strip lights,* and the *stage-floor pockets.* The footlights should be installed either in conduit or on special steel boxes which entirely enclose the lamp receptacles. Border lights must be substantially made of heavy sheet metal (at least No. 20 metal gauge) and must be wired with slow-burning wire because they necessarily get very hot from the lamps they contain.

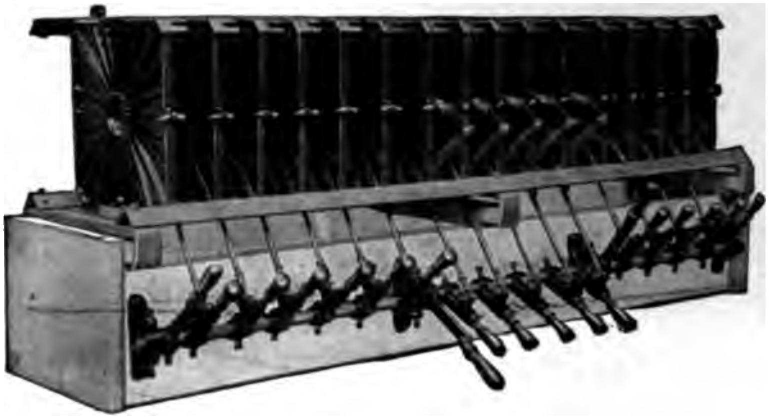

Fig. 127. Bank of Theater Dimmers

Footlights, on the other hand, do not get so hot and their location makes them susceptible to moisture during the cleaning or washing of the floor of the stage. They should, therefore, be wired with rubber-covered wire.

Border lights must be raised and lowered and, therefore, current must be carried to them by means of cables composed of stranded rubber-covered wires. Such cables should be in rigid conduit to the point where the cable leaves for the border and at this point a suitable junction box should be provided. The method of bringing the cable from this box and also of leading it into the border structure should receive special attention to prevent undue strain being brought to bear upon it at these connections. The cable should be of the special type designed for this service. Figs. 128 and 129 show sections of footlights and borders ready for installation on a stage.

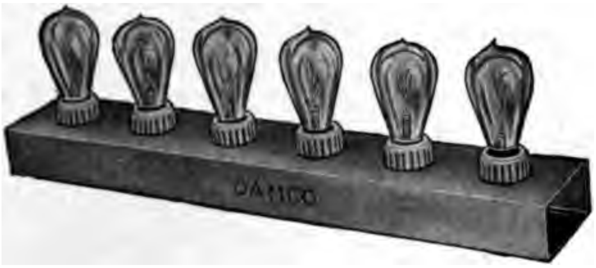

Fig. 128. Section of Theater Footlights

Stage Pockets. Stage pockets (see Fig. 130) are iron boxes, having trap doors flush with the stage floor and containing receptacles for special plugs and cables by means of which arc lamps, flood lamps, and other temporary and portable devices may be connected. The circuits should have a capacity of at least 35 amperes for arc lamps or 15 amperes for incandescent lamps, wired to the full capacity and controlled from the stage board. They should contain no fuses and should be so constructed that accumulations of dust or rubbish in them cannot interfere with their safe use or be liable to cause

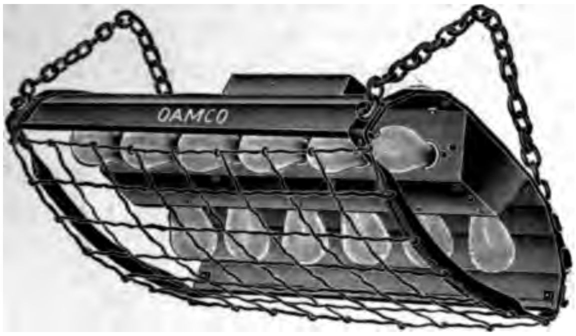

Fig. 129. Section of Theater Borders

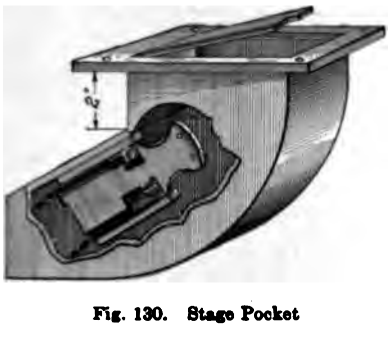

Fig. 130. Stage Pocket

a fire from any arc resulting from withdrawing the plug. These pockets may be for one or several plugs.

Portable equipments for use on theater stages include, in addition to special devices of all sorts—arc lamps, bunch lamps, strip lights, pin plug connectors, and portable plugging boxes. Fig. 131 shows a poor form of stage arc lamp of the type supposed to have caused the Iroquois theater fire in Chicago, while Fig. 132 shows a modern approved form. These should be of approved pattern, made of non-combustible materials only and fitted with standard stage cable the specifications for which are as follows: To consist of not more than three flexible copper conductors each of capacity

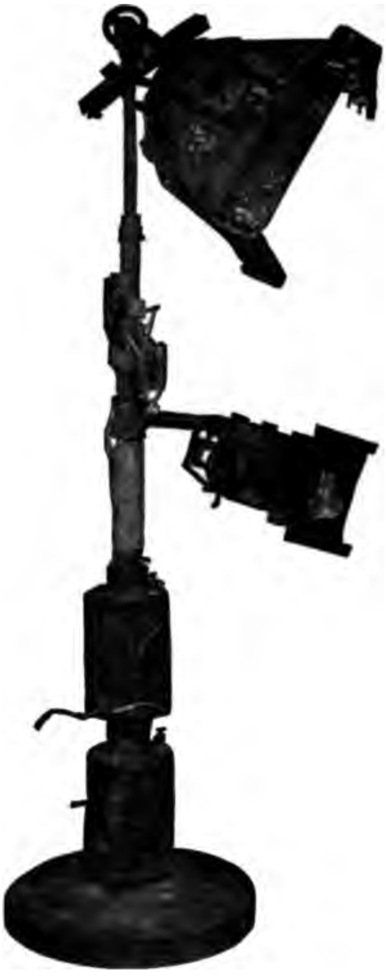

Fig. 131. Non-Approved Form of Stage Arc Lamp

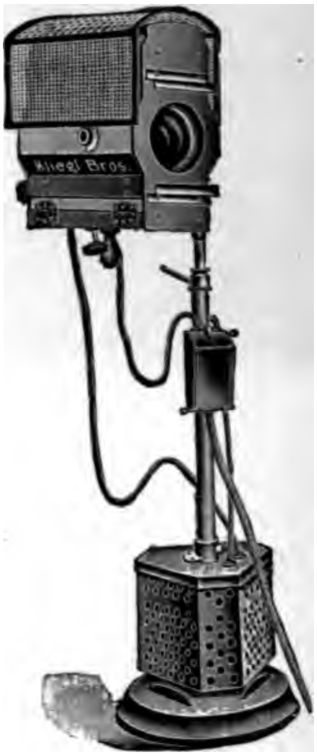

Fig. 132. Approved Form of Stage Arc Lamp

not exceeding No. 4 B. & S. gauge, built up of wires not smaller than No. 26 B. & S. gauge; each conductor to be covered with a cotton wind and with rubber insulation of thickness equivalent to standard rubber-covered wire and a saturated braid; the conductors to be twisted together with a filler (jute or a similar material) to make the cable round and to act as a cushion; the whole to be covered with two weatherproof braids. Such a cable will withstand considerable hard usage and has sufficient mechanical strength to endure the severe conditions of this service.

Special Lighting Circuits and Stage Effects. The proper installation of all of the stage devices just mentioned is such an important feature of the safety of the theater that special rules are established for portable conductors, for lights on scenery, for festoons, and for the many special effects, such as lightning, etc.

Requirements for Stage Auditoriums. The special requirements for the lighting of stage auditoriums are as follows: All wiring must be in either conduit, metal moldings, or armored cable; all fuses must be in enclosed cabinets; exit lights must not have more than one set of fuses between them and the main service fuses, and together with all hall and corridor lights, must be supplied independently of the stage lighting and be controlled only from the lobby or front of the house. All of these requirements are made to insure adequate lighting for the audience in case of a fire, to render the exit and corridor lights independent of any accident to circuits resulting from a stage fire, and to insure a certain amount of illumination at all times in order to permit firemen to work to advantage in case of a fire in the auditorium or corridors leading thereto.

MOVING PICTURE THEATERS AND MACHINES

Interior Equipment. The very large number of moving-picture theaters which have come into use in the past few years has introduced a special hazard of considerable extent and a large number of disastrous fires in such installations have been recorded. See Fig. 133. These theaters have often been established in rooms originally intended for stores and their equipment has been of the poorest character. This condition is now somewhat improved as the danger has become more generally recognized and has been made the subject of special legislation both by insurance interests and by municipal and town ordinances.

Causes of Danger. The lighting of such theaters comes under the ordinary rules for electrical work but the peculiar danger lies in the use of the arc lamp projection machines with the highly inflammable "films" on which the pictures are printed. These films

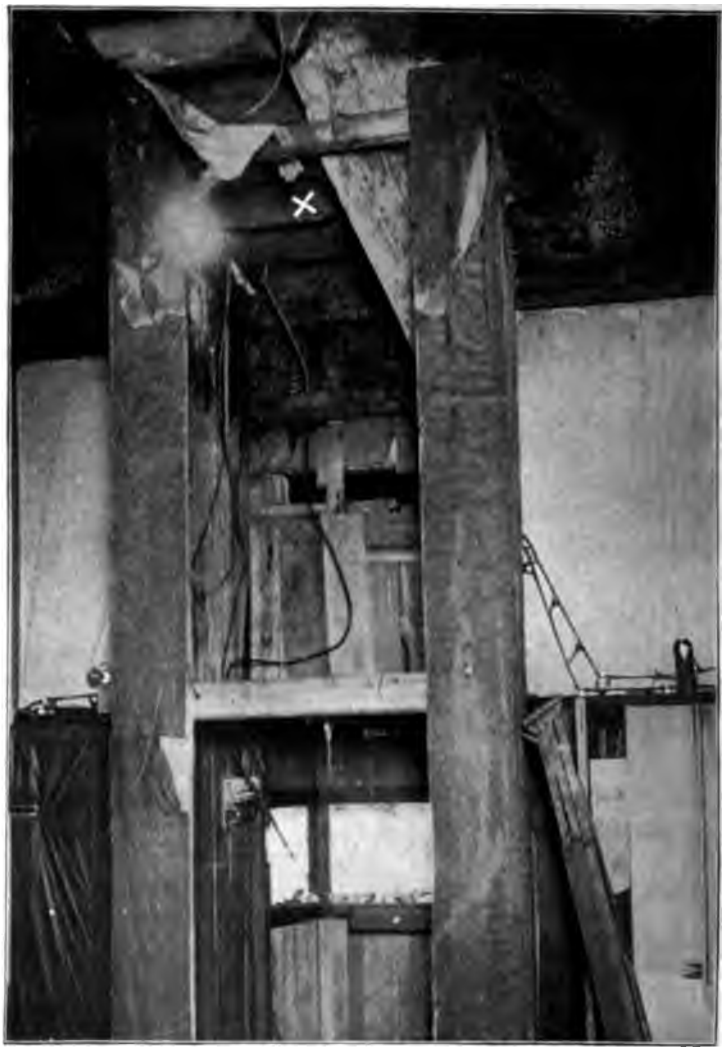

Fig. 133. Showing Fire in Moving Picture Lantern Housing Due to Inadequate Precautions

are of cellulose coated with a chemical which burns with great intensity and rapidity and with an almost explosive force. A burning film cannot be extinguished easily and evolves an enormous amount of heat and a dense and suffocating smoke. In displaying the moving pictures the film (usually 500 to 1,500 feet in length) is caused to pass rapidly in front of a special arc lamp taking from 25 to 50 amperes at 110 volts, the light and also the heat of the arc being concentrated on a small area of the film about as large as a postage stamp by means of lenses set in the head of the machine. While the machine is in normal operation, the ribbon of film is moved so rapidly that no portion of it has time to become heated. If, however, for any cause, the advance of the film is checked so that a portion of it remains for even a few seconds exposed to the concentrated heat of the arc, it is at once ignited and the flame spreads to the adjacent parts of the film and the whole reel is liable to burn up with a very intense fire which may endanger the life of the operator and create a serious fire hazard to the building. The film may also be ignited by coming into contact with the hot lamp housing or with the resistance box which it is usually necessary to use in the arc lamp circuit to regulate the current. When alternating current is used special forms of transformers or coils may be used instead of the resistance box or rheostat and these are to be preferred since they do not get so hot.

The arc lamp and rheostats should be constructed similarly to arc lamps and rheostats used on theater stages. Tight metal boxes made without solder must be used both to hold the reel from which the film is unwound in order to expose to view, and also to receive the film after it has passed through the machine head, and the openings in these boxes must be as small as possible, being regulated by rollers between which the film may pass or by shutters which can be instantly closed. The handle or crank used in operating the machine must be secured to the spindle or shaft, so that there will be no liability of its coming off and allowing the film to stop in front of the lamp. A shutter must be placed in front of the condenser, arranged so as to be readily closed. Extra films must be kept in a metal box with tight-fitting cover. Machines must be operated by hand and never by motor, since the failure of the motor, the slipping or breaking of a belt, or other like accident might stop the film. It is essential that the film and the operation of the entire equipment receive the constant attention of the operator. The picture machine must be placed in an enclosure or house made of suitable fireproof material, must be thoroughly ventilated, and should be made large enough for the operator to walk freely on either side of or back of it. All openings into this booth must be arranged so as to be entirely closed by doors or shutters constructed of the same or equally good fire-resisting material as the booth itself. Doors or covers must be arranged so as to be held normally closed by spring hinges or equivalent devices.

The construction, location, and wiring of this booth are the chief considerations in the equipment of a moving-picture theater and no pains should be spared to obtain the highest possible degree of security in every detail, in its construction and equipment, and the greatest care in its maintenance.

CAR WIRING

The electric wiring of cars requires some special rules which make certain exceptions to the general rules on the one hand and which make some special extra requirements on the other hand. These special rules have to do chiefly with the protection of car bodies and woodwork over all the electrical apparatus such as motors, resistances, contactors, and the like, and over such of the conductors as are not run in conduit. Other somewhat special requirements apply to wires, cables, and methods of making joints and connections in them, to the location and type of fuses and circuit breakers to be used, to special forms of conduit and wood molding, and to details of the lighting, heating, and air-pump circuits. Very carefully detailed requirements have been worked out for the main motor circuits and for the devices used in connection with them. As all of these requirements are of a very special character, the underwriters' rules in this connection should be studied in detail by those directly interested in car wiring.

Car houses or barns present some hazards which can be reduced by the observance of a few special rules which are determined chiefly by the fact that the railway circuit is normally grounded and thus requires somewhat different treatment from the ordinary underground light or power circuits.

LIGHTING AND POWER FROM RAILWAY WIRES

It should be especially noted that under no circumstances is it proper to take lighting or power circuits from trolley or third-rail railway circuits with a ground return. This, of course, does not and cannot apply to the electric railway cars, car houses, power, passenger and freight houses connected with the operation of electric railways in which the use of such circuits is obviously necessary and which can be specially guarded and supervised. For all other factories or buildings of all sorts, power from grounded railway circuits is forbidden because of the danger of introducing into a building a circuit which has so much capacity back of it and which is thoroughly connected with the earth on one side. The inevitable fluctuation in voltage would also frequently require overfusing of the lighting circuits to prevent blowing fuses under normal conditions.

HIGH- AND EXTRA HIGH-POTENTIAL SYSTEMS

Classification. Under low, constant-potential systems are included all such as have voltages not over 550 volts but it should be noted that this distinction is an arbitrary one adopted for the classification of the rules on electrical work in relation to the fire hazard and is not made in just this way in classifying power-transmission lines and commercial systems from other viewpoints. In the underwriters' rules any circuit attached to any machine, or combination of machines, which develops a difference of potential, between any two wires, of over 550 volts and less than 3,500 volts, shall be considered as a high-potential circuit and as coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to 550 volts or less. Similarly if the difference of potential between any two wires is over 3,500 volts the circuit is classed as an extra high-potential circuit unless an approved transforming device is used. This means that where the power is brought to a transformer on primary lines of not over 3,500 volts and the secondary lines are not over 550 volts, the secondary system of light or power is considered a low-potential system, but if the primary wires of 550 to 3,500 volts are direct to the power-consuming devices, as motors, without the outside transformer, the system is considered a high-potential system. If the primary lines are over 3,500 volts, the secondary lines beyond the transformers are classed as high-potential and where no transformer is employed the circuit is extra high-potential.

High- and extra high-potential systems are, of course, usually alternating-current circuits since only alternating current is ordinarily used for over 600 volts. There are, however, a number of railway installations in the United States operating at 1,200 volts direct current and this type of power distribution is becoming somewhat common. A 1,200-volt circuit is, of course, classed as high-potential. Use is made of high-potential circuits for both light and power purposes and its advantages over low voltages lie in the smaller sized copper that can be used to transmit a given amount of power over a certain distance with a specified percentage of loss due to the line wires.

Requirements for Safety. For lighting, 2,200- to 2,500-volt circuits are used to transmit the power from the generating station to standard transformers at or near buildings where the light is used and these transformers step down the voltage either to 110 or 220 volts or to a three-wire 110- to 220-volt system on the secondary side for the lamps. A very few cities and towns employ a 220- to 440-volt three-wire secondary system but this is not usual or desirable in general, as most fittings, fuses, etc., are designed for not over 250 volts.

Motors designed for alternating current may, of course, be operated on these secondaries and such secondary circuits whether for light or power are simply low-potential circuits provided the higher voltage lines end at transformers suitably installed outside the buildings or as near as possible to the point where the primary wires enter the buildings. The outside location is much to be preferred.

When circuits having high-potential transformers are located inside of buildings they should be placed in an enclosure made of fire-resisting material such as brick, tile, or concrete. The enclosure should be used for nothing but the transformers and should be kept locked. Fig. 134 shows such an enclosure or vault for transformers. It is a good plan to arrange the transformer room or enclosure so that it can be entered only from outdoors, since then, even if the door should happen to be open at the time of a fire in this room, it is probable that no especial harm would be done. Moreover, the fire could doubtless be better handled from the outside. The transformers must be thoroughly insulated from the ground, or permanently and effectually grounded, and the enclosure in which they are placed must be practically air-tight, except that it must be thoroughly ventilated to the outdoor air, if possible through a chimney or flue. There should be at least six inches of air space on all sides of the transformer. This rule will permit of either the insulating or grounding of transformer cases as seems most advisable under the conditions, but will require that with either arrangement the work

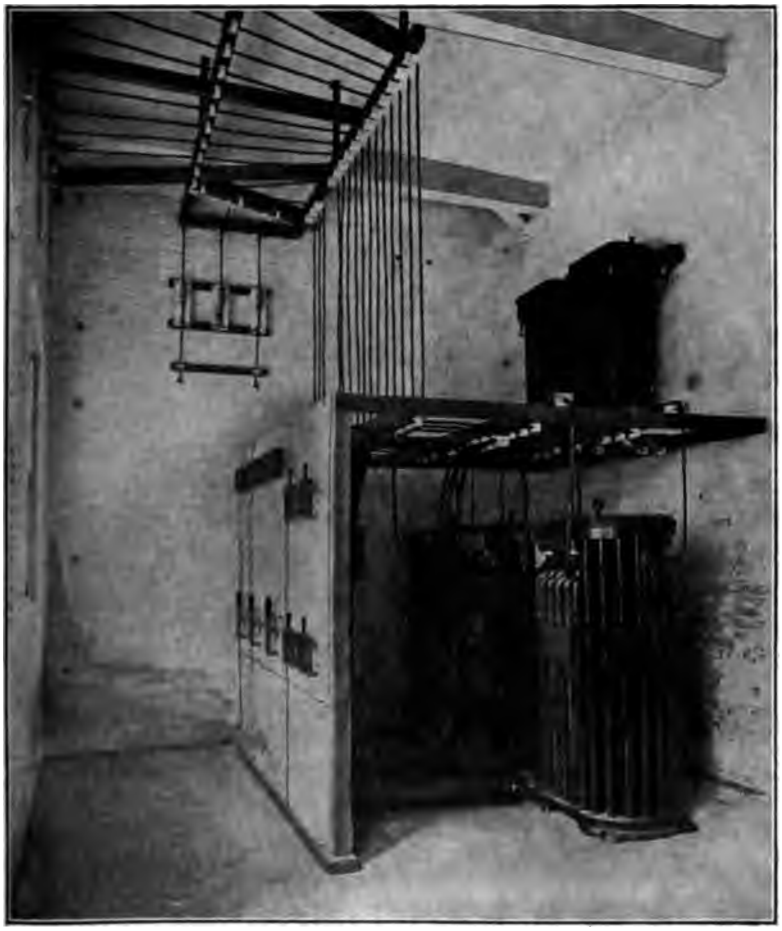

Fig. 134.* Approved Method of Protecting Transformers in a Vault

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** Courtesy Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.*

be well done, and that unless good insulation be provided the cases be definitely grounded. The object of an air-tight enclosure is to prevent smoke from escaping or fire from spreading, in case the transformer coils should become overheated from an overload or should be ignited by a break-down in the insulation between the primary and secondary coils. This is especially important with oil-cooled transformers in which the danger from an oil-fire is added to the usual electrical hazards involved.

Wherever high-potential circuits are brought into a building only rubber-covered wire should be used and special care should be taken with the wire supports to protect the wires from mechanical injury since a failure resulting in an arc is very dangerous at this high voltage. Substantial boxing about wires on side walls and running boards where circuits cross floor timbers are very necessary, as, in fact, are all the precautions and rules for good wiring and good workmanship throughout. A very large number of motors are now used taking 2,200 to 2,500 volts at the motor terminals. Such power installations can be made reasonably safe by careful planning of the circuits and by excellence of .installation and upkeep of all wiring and connected apparatus. No multiple-series or series-multiple system of lighting is allowed on high potential circuits.

Extra high-potential circuits are not allowed either in or over buildings except power stations and substations. Where extra high-potential primary circuits (over 3,500 volts) supply transformers the secondary wiring must be installed as high-potential circuits (550 to 3,500 volts) unless the primaries are installed in complete compliance with the rules governing outside work on constant-potential pole lines over 5,000 volts or are wholly underground within city, town, and village limits.

In concluding the consideration of these higher voltage circuits, it is proper to refer again to the fact that the higher the voltage employed the greater the need of care in installation, upkeep, and operation since the results of accidental arcs are more serious.

SIGNALING SYSTEMS

Wiring Requirements. The wiring and other devices in the great variety of signal systems now employed in buildings, present as a general rule no hazard except their liability to become crossed either outside or inside buildings with electric light, heat, or power circuits. Such signal systems include telephone, telegraph, district messenger and call bell, fire and burglar alarm, and all similar appliances and circuits. It is seldom that the wires of any of these systems are installed in buildings with the same care as are those for lighting or power, and the insulations employed on signal wires are very generally far inferior to those specified for light and power circuits. Furthermore, since signal systems are usually operated from either primary or secondary (storage) batteries of low voltage and limited current capacity, they may be and commonly are installed with little attention to separation of the wires, either from each other, or from the surfaces, walls, and floors to which they are attached. It follows, therefore, that all care should be taken to prevent light and power wires carrying currents of large capacity and relatively high voltages from coming in contact with signal wires since in such event dangerous fires might very readily be caused. The same advantages in having wires underground instead of being placed on poles apply to signal as well as to light and power circuits, but the two classes should never occupy the same underground duct, manhole, or handhole even when cables are used, since in the mechanical work or repairs on the lines an injury resulting in a cross between the systems might cause a dangerous current from the higher voltage lines, to outer buildings, over the weakly insulated and poorly protected signal wires. The liability of accidental crossing of overhead signaling circuits with electric light and power circuits may be guarded against to a considerable extent by endeavoring to keep the two classes of circuits on different sides of the same street. The Code prescribes that signal wires on pole lines also carrying electric light or power wires shall generally be placed on the lower cross-arms. This arrangement is not, however, favored by many engineers or by all municipal authorities, who prefer that signal wires be put on the top arms or on extensions above the tops of the poles. The arguments in favor of putting the signal wires lowest on the poles are that they are by many judged to be more liable to break and fall, especially when loaded with sleet, because of their lesser size and strength; also in case of city fire alarm circuits which are, of course, very important, the lower position enables linemen making repairs to get at the fire-alarm wires without passing up through the light and power wires which may be charged with dangerous voltages.

The arguments in favor of putting signal wires at the top are—they are small and, therefore, collect less ice or sleet and so are less liable to break; the light and power wires are often better insulated and a signal wire breaking is less liable to make a real live contact with them; the fall of a heavy power cable may wreck all of the signal wires if the latter are below; in the case of city fire-alarm circuits the upper location removes them from misuse and injury when wiremen are working on the other lines. However, it may be said that there is no *general agreement* either in theory or practice on this subject.

Single wires of signal circuits on the outside of buildings should have rubber insulation and where attached to frame buildings should be secured to glass or porcelain insulators or knobs. Only copper wire should be used for the span from the last pole to the building and the wires should pass through outside walls through insulating bushings and have drip loops the same as electric light wires. Inside of buildings neat arrangement and secure fastening of all wires is essential to keep them properly placed and no signal wire should come nearer than three inches to any light or power wire, unless separated therefrom by some continuous and firmly fixed non-conductor creating a permanent separation, this non-conductor to be in addition to the regular insulation on the wire as the wires would ordinarily be insulated, but the kind of insulation is not specified, as the protector described below is relied upon to stop all dangerous currents. Porcelain tubing, approved flexible tubing, or rigid conduit may be used for encasing wires where required as above. Wires where bunched together in a vertical run within any building should have a fire-resisting covering sufficient to prevent them from carrying fire from floor to floor unless they are run either in non-combustible tubing or in a fireproof shaft, which shaft should be provided with fire stops at each floor.

Signaling wires and electric light or power wires may be run in the same shaft, provided that one of these classes of wires is run in non-combustible tubing, otherwise the two classes of wires should be separated from each other by at least two inches. In no case should signaling wires be run in the same tube with light or power wires.

Protecting Devices. In signal installations where the current-carrying parts of the apparatus installed are capable of carrying indefinitely without overheating a current of ten amperes (as in some telegraph or special systems) the inside wires should be of copper at least as large as No. 16 B. & S. gauge and must have the same insulation and be supported the same as electric light or power wires for 600 volts. At the entrance to the building each wire should be protected by a 10-ampere 600-volt fuse. Such signal circuits as the above are much less common than those not suited for a 10-ampere current. Telephone, district messenger, private watchmen's time recorders, burglar alarms, and fire-alarm circuits, are never capable of carrying 10 amperes continuously and for these a special "protector" is required located as close as possible to the entrance of the building. The purpose of this protector is to prevent any foreign current or any lightning discharge from entering the building over the signal wires. For telegraph circuits this protector takes the form of a 2,000-volt fuse in each wire. The commoner "protector" such as is used on telephone lines should have the following parts mounted on a porcelain or slate base on which all parts are well insulated: a lightning arrester which will operate at 500 volts or more from a ground wire not less than No. 18 B. & S. gauge; a fuse in each side of the circuit which will blow with small currents ($\frac{1}{2}$ to 8 amperes) and will operate well on the voltages likely to reach the protector in case of accident. Where very sensitive instruments are in the circuit, such as contain magnet windings which are easily overheated, there must be a *heat coil* on each side of the line. The heat coil is designed to warm up and melt out with a current large enough to endanger the instruments if continued for a long time, but so small that it would not blow the fuses ordinarily found necessary for such instruments. The smaller currents are often called *sneak* currents. On

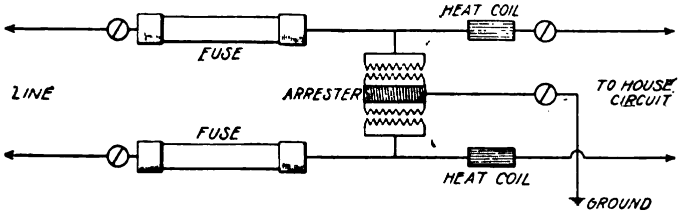


Fig. 135. Circuit Showing Proper Placing of Protecting Devices

those telephone circuits which are supplied with current entirely from the central telephone headquarters sneak or heat coils are not necessary. The fuses must be so placed as to protect the arrester and heat coils, and the protector terminals must be plainly marked *line*, *instrument*, or *ground*.

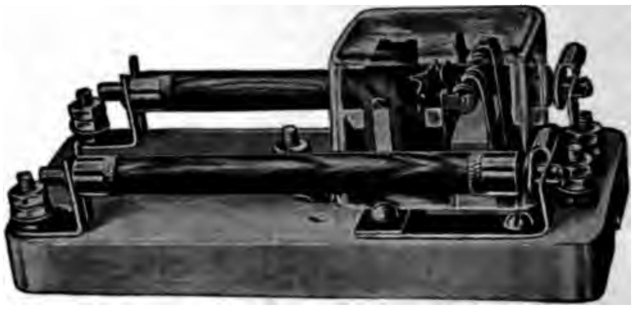


Fig. 136. Common Form of Telephone Protector

The relative arrangement of parts is shown in diagram in Fig. 135 and a common form of protector in Fig. 136.

TESTING

Where possible, two tests of the electric wiring equipment should be made, one after the wiring itself is entirely completed, and switches, cut-out panels, etc., are connected; and another one after the fixtures have all been installed. The reason for this is that if a ground or short-circuit is discovered before the fixtures are installed, it is more easily remedied; and also, because there is no division of the responsibility, as there might be if the first test were made only after the fixtures were installed. If the test shows no grounds or short-circuits before the fixtures are installed, and one does develop after they are installed, the trouble, of course, is that the short-circuit or ground is one or more of the fixtures. As a matter of fact, it is a wise plan always to make a separate test of each fixture after it is delivered at the building and before it is installed.

While a *magneto* is largely used for the purpose of testing, it is at best a crude and unreliable method. In the first place, it does not give an indication, even approximately, of the total insulation resistance, but merely indicates whether or not there is a ground or short-circuit. In some instances, moreover, a magneto test has led to serious errors, for reasons that will be explained. If, as is nearly always the case, the magneto is an alternating-current instrument, it may sometimes happen—particularly in long cables, and especially where there is a lead sheathing on the cable—that the magneto will ring, indicating to the uninitiated that there is a ground or short-circuit on the cable. This may be, and usually is, far from being the case; and the cause of the ringing of the magneto is not a ground or short-circuit, but is due to the capacity of the cable, which acts as a condenser under certain conditions, since the magneto producing an alternating current repeatedly charges and discharges the cable in opposite directions, this changing of the current causing the magneto to ring. Of course, this defect in a magneto could be remedied by using a commutator and changing it to a direct-current machine; but as the method is faulty in itself, it is hardly worth while to do this.

A portable *galvanometer* with a resistance box and Wheatstone bridge, is sometimes employed; but this method is objectionable because it requires a special instrument which cannot be used for many other purposes. Furthermore, it requires more skill and time to use than the *voltmeter* method, which will now be described.

Voltmeter Method. The advantage of the voltmeter method is that it requires merely a direct-current voltmeter, which can be used for many other purposes, and which all engineers or contractors should possess, together with a box of cells having a potential of preferably over 30 volts. The voltmeter should have a scale of not over 150 volts, for the reason that if the scale on which the battery is used covers too wide a range (say 1,000 volts) the readings might be so small as to make the test inaccurate. A good arrangement would be to have a voltmeter having two scales—say, one of 60 and one of 600—which would make the voltmeter available for all practical potentials that are likely to be used inside of a building. If desired, a voltmeter could be obtained with three connections having three scales, the lowest scale of which would be used for testing insulation resistances.

Before starting a test, all of the fuses should be inserted and switches turned on, so that the complete test of the entire installation can be made. When this has been done, the voltmeter and battery should be connected, so as to obtain on the lowest scale of the voltmeter the electromotive force of the entire group of cells. This connection is shown in Fig. 137. Immediately after this has been done, the insulation resistance to be tested is placed in circuit, whether the insulation to be tested is a switchboard, slate panel-board, or the entire wiring installation; and the connections are made as shown in Fig. 138. A reading is again taken of the voltmeter and the leakage is thus obtained, as it is in proportion to the difference between the first and second voltmeter readings. The explanation given below will show how this resistance may be calculated. It is evident that the resistance in the first case was merely the resistance of the voltmeter and the internal resistance of the battery. As a rule, the internal resistance of the battery is so small in comparison with the resistance of the voltmeter and the external resistance, that it may be entirely neglected, and this will be done in the following calculation. In the second case, however, the total resistance in circuit is the resistance of the voltmeter and the battery, *plus* the entire insulation resistance on all the wires, etc., connected in circuit.

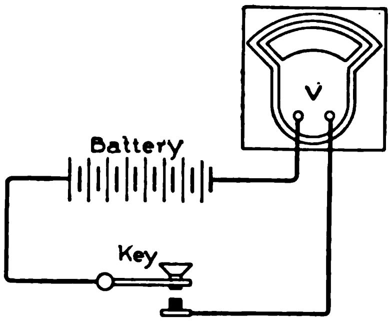


Fig. 137. Connections for Voltmeter Test Before Circuit is Connected

To put this in mathematical form, the voltage of the cells may be indicated by the letter E; and the reading of the voltmeter when

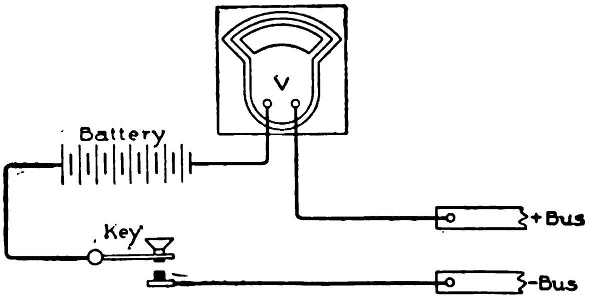


Fig. 138. Connections for Voltmeter Test with the Insulation to be Tested in Circuit

the insulation resistance is connected by the circuit, by the letter E'. Let R represent the resistance of the voltmeter and R_x represent the insulation resistance of the installation which we wish to measure. It is a fact which the reader undoubtedly knows, that the e. m. f. as indicated by the voltmeter in Fig. 138 is inversely proportional to the resistance; that is, the greater the resistance, the lower will be the reading on the voltmeter, as this reading indicates the leakage or current passing through the resistance. Putting this in the shape of a formula, we have from the theory of proportion

$$E : E' :: R+R_x : R$$

or

$$E'\,R+E'\,R_x=E\,R$$

Transposing

$$E'\,R_x=E\,R-E'\,R=R\,(E-E')$$

and

$$R_x=\frac{R\,(E-E')}{E'}$$

Or, expressed in words, the insulation resistance is equal to the resistance of the voltmeter *multiplied by* the difference between the first reading (or the voltage in the cells) and the second reading (or the reading of the voltmeter with the insulation resistance in series with the voltmeter), *divided by* this last reading of the voltmeter.

Example. Assume a resistance of a voltmeter R of 20,000 ohms, and a voltage of the cells E of 30 volts; and suppose that the insulation resistance test of a wiring installation, including switchboard, feeders, branch circuits, panel-boards, etc., is to be made, the insulation resistance being represented by the letter R_x. By substituting in the formula

$$R_x=\frac{R\,(E-E')}{E'}$$

and assuming that the reading of the voltmeter with the insulation resistance connected is 5, we have

$$R_x=\frac{20{,}000\times(30-5)}{5}=100{,}000 \text{ ohms}$$

If the test shows an excessive amount of leakage, or a ground or short-circuit, the location of the trouble may be determined by the process of elimination—that is, by cutting out the various feeders until the ground or leakage disappears, and, when the feeder on which the trouble exists has been located, by following the same process with the branch circuits.

Of course, the larger the installation and the longer and more numerous the circuits, the greater the leakage will be; and the lower will be the insulation resistance, as there is a greater surface exposed for leakage. The rules of the Code give a sliding scale for the requirements as to insulation resistance, depending upon the amount of current carried by the various feeders, branch circuits, etc. The rule of the Code covering this point, is as follows:

> The wiring in any building must test free from grounds; *i. e.*, the complete installation must have an insulation between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) not less than that given below:

Up to 5 amperes	4,000,000 ohms
Up to 10 amperes	2,000,000 ohms
Up to 25 amperes	800,000 ohms
Up to 50 amperes	400,000 ohms
Up to 100 amperes	200,000 ohms
Up to 200 amperes	100,000 ohms
Up to 400 amperes	50,000 ohms
Up to 800 amperes	25,000 ohms
Up to 1,600 amperes	12,500 ohms

> The test must be made with all cut-outs and safety devices in place. If the lamp sockets, receptacles, electroliers, etc., are also connected, only one-half of the resistances specified in the table will be required.

DEVICES AND MATERIALS

No care in installing electrical equipments will entirely compensate for the use of inferior or defective devices or materials. The National Board of Fire Underwriters has for many years maintained a system of tests and examinations of electrical appliances, and issues twice a year a "List of Electrical Fittings" which contains in a classified form under the names of their manufacturers all of the standard and special fittings and materials which have been approved. These tests and examinations are made and the approvals are issued by Underwriters' Laboratories, Inc., a thoroughly equipped institution maintained in Chicago by the fire insurance interests, for the express purpose of examining and testing all kinds of devices and materials, electrical and otherwise, which have any bearing whatsoever on the fire hazard. This "List of Fittings" issued semiannually, is universally recognized as the only complete and reliable guide to properly safeguarded electrical appliances and it should be consulted and followed in the choice and purchase of supplies. The Underwriters' Laboratories also maintain an elaborate system whereby manufacturers may obtain and place on their wares special labels issued by the Laboratories, which thus become a guarantee on the goods themselves that the articles bearing such labels are in conformity with underwriters' rules and have been examined and tested by special underwriters' inspectors at the factories where they are made. This system of label service and inspection is not yet extended to all classes of approved electrical devices, but for those classes of appliances which are now included, the label may be regarded as affording to prospective purchasers and users reliable evidence not only of the general approval of the design but also that the particular sample bearing the label is made in accordance with requirements and is suitable for use.

The constructional details of electrical fittings and materials together with the chief tests to which they are subjected, prior to approval, are contained in what is known as "Class D" of the Code. This pamphlet should be consulted for full details or inquiry should be addressed to Underwriters' Laboratories, 207 East Ohio Street, Chicago, Illinois, for information not given in the Code or in the semi-annual "List of Fittings."

In the following pages is given a brief discussion of the chief characteristics and requirements of some of the more common materials and of the more important classes of devices used in electrical construction work.

RUBBER-COVERED WIRE

General Specifications. A considerable variety of grades of rubber-covered wire is manufactured, some makers offering several grades and others only one or two at most. The chief distinction lies in the quality and quantity of real new, pure, fine rubber gum used in the compound. It is not possible to determine or grade the excellence of a rubber compound by any direct or readily applied tests, but somewhat elaborate tests, physical, chemical, and elec-

TABLE IV

Thickness of Rubber Insulation

B. & S. Gauge	Thickness
18 to 16	1-32 inch
15 to 8	3-64 inch
7 to 2	1-16 inch
1 to 0000	5-64 inch
Circular Mils	
250,000 to 500,000	3-32 inch
500,000 to 1,000,000	7-64 inch
Over 1,000,000	1-8 inch

trical, are necessary to arrive at any correct estimate. The following properties of good wire may, however, be noted. The rubber should be neither hard and dry, nor soft and spongy. When examined minutely it should appear of a close uniform texture free from small bits of unmixed matter or pinholes. It should adhere closely to the tinned copper. The thickness of rubber wall should correspond to the data given in Table IV.

Measurements of insulating wall are to be made at the thinnest portion of the dielectric and it should be very carefully noted whether the copper is exactly centered in the rubber covering so that the full prescribed insulation is maintained on all sides.

The rubber insulation should exhibit a fair degree of elasticity when pieces cut from the wire are stretched and released. If the rubber breaks with a very slight pull and shows no ability to stretch and recover its first length it is probable that a very poor grade of gum has been used, or that the manufacturing process is defective, or both.

After the braid has been carefully removed it should be possible to wind the smaller sizes of wire about a cylinder of the same diameter as the rubber-covered wire without the rubber showing any breaks or cracks either at once or after several days.

The foregoing should be considered as only rough tests and not susceptible of exact application except under conditions which can be maintained in a regular testing laboratory. No directions can be given which will permit any but an expert chemist to make chemical examinations of rubber compounds.

The braids should be of close weave and should be very thoroughly saturated with the compound. All wires should have through their entire length a marker indicating by whom they were made and each coil should bear a tag giving, beside the maker's name, the maximum voltage for which it is designed, the words "National Electrical Code Standard," and the month and year when it was manufactured. Every coil of approved wire is separately tested by the maker at the factory by at least two electrical tests, one designed to show that the insulation is free from mechanical defects and the other to show at least a minimum insulation value.

Special Insulation. Most makers are prepared to furnish at a special price a grade of wire commonly known as "thirty per cent Para." This wire is understood to have an insulation containing at least 30 per cent of "fine, pure, up-river Para" gum which is much more than common commercial rubber-covered wire contains. This 30 per cent wire is also made according to certain rather exacting specifications designed to insure a high grade of insulation with good lasting properties. Wire of this description is often specified where an extra good quality is desired for first class work.

A good compound should contain a large percentage of pure, fine, new rubber of excellent quality. Para rubber is universally admitted to be the best for imparting life, strength, and durability to the insulation. The use of reclaimed rubber or any of the so-called rubber substitutes reduces the excellence of the compound approximately in the proportion in which it is used. The other ingredients of a good compound are solid, waxy, hydrocarbons, suitable mineral matter and sulphur. The sulphur plays an important part in the vulcanizing of the compound, the process whereby the rubber is transformed from its original and almost crude state into the substance familiar to us as manufactured rubber in any one of its numerous forms.

Fixture Wire. Fixtures may be wired with flexible cord or standard rubber-covered wire, and for other wires for use in fixtures, the following rules apply: The wire may be either solid or stranded and not less than No. 18 B. & S. gauge. Solid conductors must be tinned and stranded conductors must be of strands not less than No. 30 B. & S. gauge and must have a cotton wind between copper and rubber. The No. 18 wire may have a rubber insulation $\frac{1}{32}$-inch thick, but No. 16 and also flexible cord used in fixtures must have at least $\frac{1}{32}$-inch rubber. All sizes must be covered with a good braid. The concession of so thin a rubber wall on No. 18 wire has been made because a very small wire must be used to pass through the arms and other parts of many fixtures.

In wiring certain designs of show-case fixtures, ceiling bull's-eyes and similar appliances, in which the wiring is exposed to temperatures in excess of 120° F. (49° C.), from the heat of the lamps, slow-burning wire may be used.

Insulation for Conduit and Armored Circuits. For all conduit work and in all armored cable the wire is regular standard rubber-covered with an extra braid. For twin or duplex wires, this outer braid, which should be at least $\frac{1}{32}$-inch thick, is made as a covering over the two regular rubber-covered and braided conductors. These twin wires are generally used in conduit work but where single conductors are used they must also have double braid. The purpose of this extra outer braid is primarily to withstand the abrasion and strain resulting from hauling the conductors through the conduits from outlet to outlet, and the braids on the individual conductors are to hold the rubber insulation in place and prevent jamming and flattening which might reduce the thickness of rubber between the two wires and thus weaken the insulation at many points.

RIGID CONDUIT AND CONDUIT FITTINGS

Unlined Steel Conduit. The following description applies only to standard unlined steel conduit. This is made of mild steel with a butt weld joint lengthwise of the pipe. Sizes run from normal $\frac{1}{2}$-inch to 4-inch pipe. The raw pipe is thoroughly cleaned inside and outside and then given a protective coating either of an enamel baked on or of zinc applied either by electroplating or by a special process known as sherardizing. With either form of zincing the interior is given a coat of enamel also. The finished pipe should be smoothly coated and able to stand bending without injury to the enamel or the zinc. The conduit should be of sufficiently true circular section to admit of cutting true, clean threads. The enamel applied to conduit is not considered as an insulation but either enamel or zinc is required to protect the steel from rusting away and also to give a smooth surface for the conductors to be drawn over in inserting the wires. Ordinary commercial pipe should never be used as electric conduit since it is not free from rough edges, is not maintained at

TABLE V

Minimum Weights of Conduit for Required Wall Thickness

Size Inches	Pounds per 100 Feet	Size Inches	Pounds per 100 Feet
½	75	1½	250
¾	104	2	350
1	152	3	710
1¼	209		

uniform size or wall thickness, is not protected against rust and in general is not made with the care and rigid inspection which have been found by experience to be necessary for electric conduits. Table V gives the minimum weights per 100 feet of finished conduit which are required to give the specified thickness of wall.

Conduit Fittings. A very great variety of boxes and small fittings for use with conduit is available. All boxes including flush switch boxes should be either of cast iron with walls at least ⅛-inch thick or of sheet steel at least .078 inch thick. They must be well enameled or galvanized to protect them from rusting and must have no openings not closed by the entering pipes, by a metal cover of the same thickness of the box or by the switch, receptacle, or canopy of the device attached to them. Under no circumstances is it allowable to place any such box so that it will not be accessible. There should be no rough edges or corners which are liable to injure the coverings of wires as they are drawn in. Fig. 139 shows the form of a common type of box. Boxes for use with combination gas and electric fixtures must be provided with an arrangement for making a tight electrical connection between the box and the gas pipe at each outlet so that there may be no arcing between box and pipe in case any failure of wire insulation causes a current to flow over the box. Otherwise such an arc may burn a hole in the gas pipe and ignite the gas. All threaded parts of boxes and all threads on locknuts and metal bushings must be clean cut and well fitted in order to insure that permanent and reliable electrical continuity of the conduit system which is one of the chief requirements for conduit work.

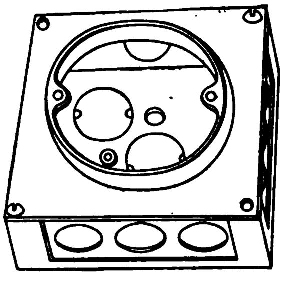


Fig. 139. Common Type of Outlet Box

Set screw connections have been found unsatisfactory as they loosen with the vibration of buildings and with changes of temperature, and only regular screwed thread joints or substantial clamps should be used at all conduit and armored-cable connections.

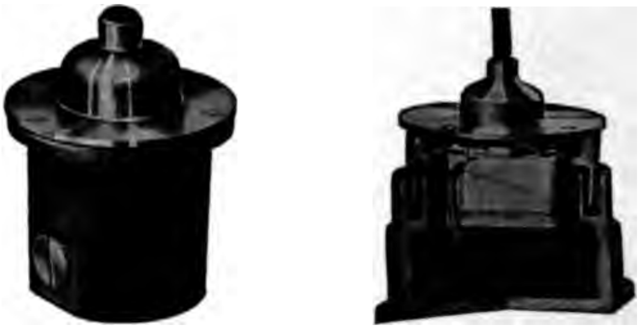


Fig. 140. Common Form of Floor Outlet Box

Where a floor outlet in a conduit system is desired, a special type of box should be used known as a floor outlet box. Such boxes (see Fig. 140) provide ample room for making splices in wires, for mounting receptacles or other fittings and especially provide a substantial, watertight top or cover which can be set flush with the floor surface. The practice sometimes followed of setting flush wall receptacles in floors is to be strongly condemned since such fittings are not strong enough for such service and are not watertight, thus permitting water to enter the conduit box and system.

FUSES OR CUT-OUTS

Classification. Three forms of fuses are at present employed in this country for general wiring work, *open-link* fuses, *cartridge* fuses and *plug* fuses, the last two being further described as enclosed fuses to distinguish them from the open links. The bases to which or in which the fuses are secured are called cut-outs.

Link fuses are extensively used on large switchboards and their use on such boards is open to less objection than for general wiring since such boards are usually under expert supervision and located in well-protected or fireproof rooms. With link fuses there is always the possibility of a larger fuse being put into the cut-out than it was designed for, which is not true of enclosed fuse cut-outs classified as

TABLE VI
Open-Link Fuse Spacing

	Minimum Separation of Nearest Metal Parts of Opposite Polarity Inches	Minimum Break Distance Inches
125 Volts or less		
10 amperes or less	$\frac{3}{4}$	$\frac{3}{4}$
11-100 amperes	1	$\frac{3}{4}$
101-300 amperes	1	1
301-1000 amperes	$1\frac{1}{4}$	$1\frac{1}{4}$
126 to 250 Volts		
10 amperes or less	$1\frac{1}{2}$	$1\frac{1}{4}$
11-100 amperes	$1\frac{3}{4}$	$1\frac{1}{4}$
101-300 amperes	2	$1\frac{1}{2}$
301-1000 amperes	$2\frac{1}{2}$	2

required below. Again, the voltage in most plants can, under some conditions, rise considerably above the normal. The need of some margin, as a factor of safety to prevent the cut-outs from being ruined in ordinary service, is therefore evident. When tablet-boards or single fuse-blocks with such open-link fuses on them are used in general wiring, they must be enclosed in cabinet boxes. This is necessary, because a severe flash may occur when such fuses melt, so that they would be dangerous if exposed in the neighborhood of any combustible material. Link fuses should never be mounted on porcelain cut-outs because a severe short-circuit is liable to break this rather fragile material and the molten metal is apt to fuse into the porcelain, partly reducing its insulating properties.

There is no filler surrounding the fusible metal of open links and, therefore, the ability of the fuse to open the circuit depends on having enough of the metal burned away, when the fuse blows, to break the arc. For this reason the terminals for link fuses, as far as practicable, should be made of compact form instead of being rolled out in thin strips; and sharp edges or thin projecting pieces, as on wing thumb nuts and the like, should be avoided. Thin metal, sharp edges, and projecting pieces are much more likely to cause an arc to start than a more solid mass of metal. It is a good plan to round all corners of the terminals and to chamfer the edges. Plain fuse wire or fuse strip should never be used for links but only fuses made up with solid metal terminals as shown in Fig. 17.

In general work open-link fuses should not be used on circuits of voltages above 250 volts and where large currents are involved the use of approved circuit breakers is very much to be preferred to extra large link fuses. The spacings for open-link fuses are given in Table VI.

Plug Fuses. The form of fuse which is used in larger numbers than those of any other type, is shown in Fig. 141. Fig. 142 shows one of the many forms of cut-out bases for plug fuses and Fig. 57 shows similar blocks arranged in an asbestos-lined cabinet to make a tablet or panel-board for distributing current to branch-lighting circuits. The cabinet should have a tightly fitted asbestos-lined or metal-lined door. Plug fuses are approved for use only on circuits of not over 125 volts, including 3-wire circuits with grounded neutral, and not over 250 volts between outside wires. Fig. 143 shows the effect if the fuses are blown on a 220-volt circuit. These plugs are limited to ratings of 30 amperes and less because their form and strength is not such as to make them safe for use with larger currents. They are, therefore, chiefly adapted for small lighting and motor branch circuits. They are decidedly safer than open-link fuses of equal capacity and are cheaper than enclosed cartridge fuses.

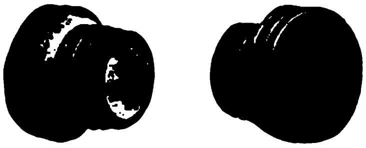


Fig. 141. Standard Fuse Plug

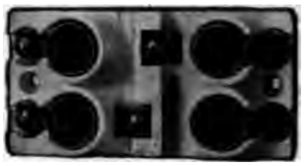


Fig. 142. Cut-Out Base for Fuse Plugs

There are a number of patterns of unapproved plug fuses on the market which should be avoided as they usually lack some of the essential properties of safe fuses, although they may appear from casual inspection to be almost identical with them. It is unfortunately true that plug fuses of the present form can be "doctored" in several ways so as to carry larger currents than they should. Tin-foil, solder, and bits of copper wire are often found put around or into plug fuses so as to completely destroy their usefulness as protective devices. Inspectors and property owners should be on the lookout for this highly dangerous practice and also observe carefully whether plugs of too large current capacity have been substituted for those of ratings which afford real protection to the wiring of the circuits of which they are a part.

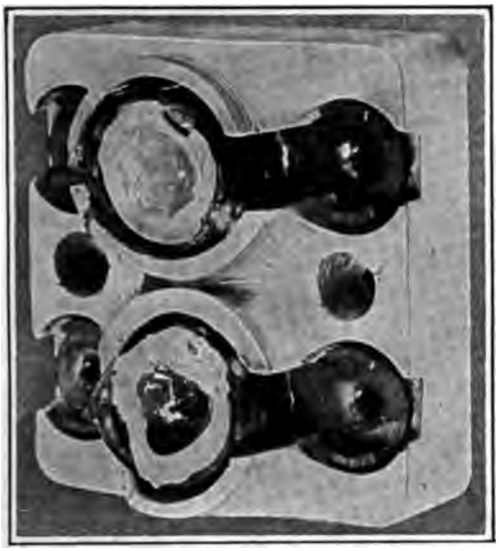
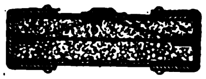
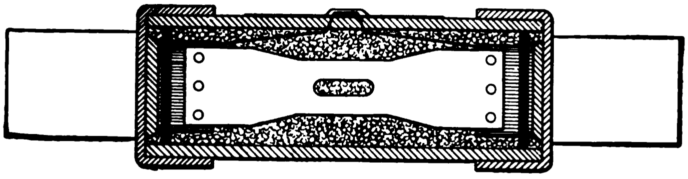


Fig. 143. Effect of Plug Fuses Blown on 220-Volt Circuit

Cartridge Fuses. A cartridge fuse consists of a cylindrical tube of fiber or strong paper to which are fitted metal caps by means of which connection is made to the cut-out terminals. Within the tube is the fusible metal wire or strip extending between and firmly secured to the inside of the caps. The tube is filled with a powdered or granulated material packed closely about the fusible strip. The purpose of this filler is to conduct the heat from the strip to the outer



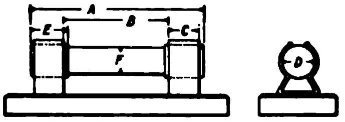
0-30 AMPERES 250 VOLTS



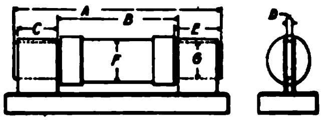
101-200 AMPERES 250 VOLTS

Fig. 144. Sections through Cartridge Fuses Showing Construction

casing, to smother the arc when the fuse blows, to make it possible to adjust more exactly the carrying capacity of the fusible strip, and to absorb some of the gases evolved from the molten metal. The chief ingredients of fillers now used are magnesia and plaster of Paris. Fig. 144 shows in section the internal construction of two typical cartridge fuses of 30 and 200 amperes capacity. The illustration is full size. The small wire extending from one terminal to a point on the tube and thence to the other terminal is designed to burn off at the tube when the fuse blows and fuse a bit of powder under a slip of thin paper on the outside of the casing, thus indicating that the fuse has operated. As will be seen from the description a cartridge fuse will confine the arc, flame, or molten metal within the filler and tube when its fusible element is melted by an overload or by a short-circuit and is, therefore, a safer device than an open-link fuse.



STYLE OF TERMINAL FOR CARTRIDGE FUSES 0-60 AMPERES
FORM 1. FERRULE CONTACT



STYLE OF TERMINAL FOR CARTRIDGE FUSES 61-600 AMPERES
FORM 2. KNIFE-BLADE CONTACT

			A	B	C	D	E	F	G		
VOLTAGE	RATED CAPACITY		LENGTH OVER TERMINALS	DISTANCE BETWEEN CONTACT CLIPS	WIDTH OF CONTACT CLIPS	DIAMETER OF FERRULES OR THICKNESS OF TERMINAL BLADES	MIN. LENGTH OF FERRULES OR OF TERMINAL BLADES OUTSIDE OF TUBE	DIAMETER OF TUBE	WIDTH OF TERMINAL BLADES		RATED CAPACITY
	AMPERES		INCHES	INCHES	INCHES	INCHES	INCHES	INCHES	INCHES		AMPERES
0-250	0-30 31-60	FORM 1	2 3	1 1 3/4	1/2 5/8	9/16 13/16	1/2 5/8	1/2 3/4		FORM 1	0-30 31-60
	61-100 101-200 201-400 401-600	FORM 2	5 7/8 7 1/8 8 5/8 10 3/8	4 4 1/2 5 6	7/8 1 1/8 1 5/8 2 1/8	1/8 3/16 1/4 1/4	1 1 3/8 1 7/8 2 1/8	1 1 1/2 2 2 1/2	3/4 1 1/8 1 5/8 2	FORM 2	61-100 101-200 201-400 401-600
251-600	0-30 31-60	FORM 1	5 5 1/2	4 4 1/4	1/2 5/8	13/16 1 1/16	1/2 5/8	3/4 1		FORM 1	0-30 31-60
	61-100 101-200 201-400	FORM 2	7 7/8 9 5/8 11 5/8	6 7 8	7/8 1 1/8 1 5/8	1/8 3/16 1/4	1 1 3/8 1 7/8	1 1/4 1 3/4 2 1/2	3/4 1 1/8 1 5/8	FORM 2	61-100 101-200 201-400

Fig. 145. Dimensions and Classifications of Cartridge Fuses

In 1905 a standardization of cartridge fuses and their cut-out bases was agreed upon in order to bring them all to uniform dimensions, to arrange the different ratings under a classification which would make it impossible to put a large fuse into a cut-out base of a smaller class, and to make it possible to use any approved fuse in any approved base whether fuse and base were of the same or different make. Under this classification two types of terminals were standardized known as *ferrule* and *knife-blade* contacts, and the current ratings were grouped into two sizes for the ferrule and four sizes for the knife-blade contacts. The dimensions and classification are fully shown on the diagrams and in the table, Fig. 145.

Knife Switches. Knife switches must always be mounted on separate bases of slate, marble, or porcelain, or on slate or marble switchboards or panels. The parts carrying the contact clips and the blade hinges must be secured to the base by two screws, a screw and a dowel-pin, or otherwise, so that the parts will always be in correct alignment. If the contact jaws or hinge clips get turned so as to be out of line, it may be impossible to close the switch, especially at the first attempt, and severe arcing may result from the efforts to do so. Even if the blade enters the jaws, the contact may be imperfect, causing undesirable heating. The chief points to note in judging a knife switch are the following: Excellence of fit of blades both at the hinge and in the contact clips; stiffness and size of all metal parts to secure good contact surfaces and ample carrying capacity. No part should become heated over 50° F. when the switch is carrying its full rated current, and at all sliding contacts there should be at least 1 square inch of surface contact for every 75 amperes of current. The cross bars should be very securely fastened to the blades and the workmanship throughout should be excellent. If each blade is secured to the cross bar by only one screw, without dowel-pins or a square shoulder fitting closely in a recess in the bar, a slight loosening of the screws will allow one blade to close and open the circuit before the other, resulting in arcing and ultimate injury to the switch. Such construction is also liable to result in a weak switch. Too little attention is frequently given the question of mechanical strength, with the result that after a comparatively short time of service the switches rattle to pieces or break unless very carefully handled, and even then repairs are often necessary to keep them in working order. A cheap switch is seldom a rugged, durable device. All switches should be marked with the name of their maker and the rating in both volts and amperes.

The spacings of switches must be at least as great as those given in the Code, a copy of which is given in the following table. This table specifies the limits necessary for both direct-current and alternating-current systems.

TABLE VII

Approved Spacing for Knife Switches

	Minimum Separation of Nearest Metal Parts of Opp. Pol. Inches	Minimum Break Distance Inches
Not over 125 Volts D. C. and A. C. for Switchboards and Panel Boards*		
10 amperes	¾	½
30 amperes	1	¾
60 amperes	1¼	1
Not over 125 Volts D. C. and A. C. for Individual Switches†		
30 amperes	1¼	1
60 and 100 amperes	1½	1¼
200 and 300 amperes	2¼	2
400 and 600 amperes	2¾	2½
800 and 1,000 amperes	3	2¾
250 Volts only D. C. and A. C. for All Switches		
30 amperes	1¾	1½
Not over 250 Volts D. C. nor over 500 Volts A. C. for All Switches‡		
30, 60 and 100 amperes	2¼	2
200 and 300 amperes	2½	2¼
400 and 600 amperes	2¾	2½
800 and 1,000 amperes	3	2¾
Not over 600 Volts D. C. and A. C. for All Switches**		
30 and 60 amperes	4	3½
100 amperes	4½	4

*The 10-ampere switch must have ample metal for stiffness, and to prevent rise in temperature of any part of more than 50 degrees Fahrenheit when carrying 30 amperes, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surface advised for pure copper blades of about 0.4 square inch.

†The 300-ampere switch must not be equipped with cut-out terminals.

‡The above switches must be stamped "250 V. D. C., 500 V. A. C." The 30-ampere switch must have ample metal for stiffness, and to prevent rise in temperature of any part of more than 50 degrees Fahrenheit when carrying 60 amperes, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces advised for pure copper blades of about 0.8 square inch. The 300-ampere switch must not be equipped with cut-out terminals. Cut-out terminals on switches for over 250 volts must be designed and spaced for 600 volt fuses, and in such cases the switches must be stamped "500 V. A. C."

**The 30-ampere switch must have ample metal for stiffness, and to prevent rise in temperature of any part of more than 50 degrees Fahrenheit when carrying 60 amperes, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces advised for pure copper blades of about 0.8 square inch.

Auxiliary breaks or the equivalent are recommended for D. C. switches designed for over 250 volts and must be provided on D. C. switches designed for use in breaking currents greater than 100 amperes at a voltage of over 250.

NOTE. For three-wire direct-current and three-wire single-phase systems the separations and break distances for plain three-pole knife switches must not be less than those required in the above table for switches designed for the voltage between the neutral and outside wires.

Snap Switches. Under this term are included the *common round base surface* switches, the *rotary* and *push-button* switches, which are set in boxes in side walls flush with the surface, *pendant* switches, and all such as are operated by the motion of doors, by a cord and all switches mounted on fixtures. The distinguishing feature of them all consists in the fact that the motion of the parts which open and close the circuit is produced by a spring contained in the mechanism. As the handle or button is turned or pushed this spring is wound up and at the proper tension is released, thus throwing the switch blades into or out of the contacts. Thus the quickness with which the circuit is opened or closed is not directly determined by the motion of the operator's hand but by the spring, and if the switch is of proper design and in good condition, the action is prompt and reliable even though the person using the switch is not careful to do just the right thing. Such snap switches, therefore, differ from knife-blade switches in that their proper use does not depend upon the user and they are correspondingly better suited for general purposes for unskilled persons.

The bases should be of non-combustible material, usually porcelain, and all covers should be lined with a non-conducting material such as fiber unless they are of porcelain. Without this lining there is danger of the cover forming a short-circuit in the switch, especially if the cover is removed or replaced while the switch is "alive." The side lining should extend beyond the lower edge of the cover.

The binding posts should be of a type in which the end of the connected wire is held under a screw head or equivalent device and not by a set-screw the end of which drives against the side of the wire, as a set-screw is likely to become loosened and is almost sure to cut into the wire. Indicating switches are much preferred for all work, as by showing at once whether the current is "on" or "off" they tend to save mistakes and possible accidents. The fact that lights do not burn or that a motor does not run is not necessarily a sure sign that the current is off, but the indicating switch makes it possible to tell at a glance whether the circuit is open or closed.

Fig. 146 shows a variety of approved snap switches of common type. Snap switches to be approved are required to operate successfully at 50 per cent excess current above that for which they are rated at the voltages for which they are designed. This is to provide a margin of safety but should not be made an excuse for using them for larger currents than those marked on them. They are made in a great variety of sizes and patterns, single- and double-pole, three- and four-way, and in special designs for turning on the lamps of a chandelier one after the other or for controlling small motors or heating devices. The standardized ratings include 125, 250, and 600 volts for currents of 3, 5, and 10 amperes in the more commonly used patterns. Certain large-sized double-pole surface snap switches are rated at 20 or 30 amperes while a few of the more special and less substantial forms are limited to 1 ampere only. In judging snap switches of all kinds samples are tested by Underwriters' Laboratories in the following way: they are connected to control groups of lamps taking full rated current of the switch at full rated voltage and are then put on a special machine which operates them slowly and continuously for 6,000 cycles, that is 6,000 full "on and off" operations. It is required that the samples stand this endurance test without failing either mechanically or electrically. This test is re-applied to new and recent samples from time to time, and similar

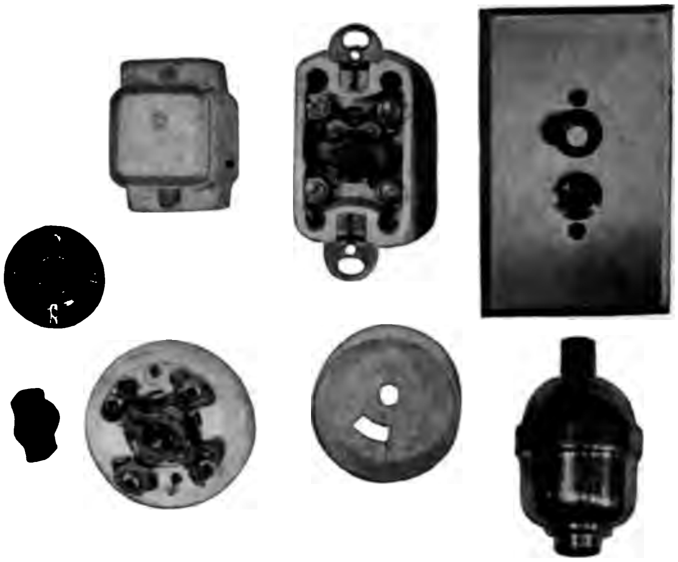


Fig. 146. Group of Approved Snap Switches

tests are constantly in progress at the factories where the switches are made, so that any important defect in material or construction is soon detected and a fairly uniform grade of snap switches is sure to be produced for the user. Such persistent tests have done much to improve the quality of these and other electrical products.

CIRCUIT BREAKERS

Circuit breakers are automatic switches so designed that an excess current will cause the switch to open. They thus share the properties of both switches and protective devices such as fuses, and in their choice and installation both functions must be considered. Breakers are made for currents of all capacities and for circuits of every voltage both d. c. and a. c. Those most commonly used on lighting and power switchboards and in general commercial work are for voltages of 600 volts or less (occasionally 2,000 volts). For higher voltages the breakers are of massive form and are often set in *cells* or compartments of brick, slate, or concrete. Such breakers are employed only where expert supervision is always available and their form and operation is, therefore, not prescribed by underwriters' rules but rather by the engineering necessities of the system of which they are a part.

The ordinary commercial breaker as used on low-voltage circuits may be one, two, or three poles and these may be independent of each other or may be interlocked so that an overload on any one wire will cause all the lines to be opened. The latter is preferable. Breakers are usually made with an adjustment regulating the point at which they will open. Thus a 100-ampere breaker may be set to open at any current with a certain range above and below 100 amperes.

In installing breakers the same care should be taken as with fuses of like capacity. They should never be placed near any inflammable material, as their operation under severe overloads results in a severe though brief arc and often in the spattering of bits of molten metal quite capable of igniting waste, shavings, etc. The use of circuit breakers instead of fuses is to be recommended for very large currents and for all circuits such as many motor circuits where operating conditions are liable to produce frequent overloads.

Classification. Circuit breakers may be divided into two chief classes, *carbon* or *air-break* patterns and *oil-immersed* patterns. The former may be used on either d. c. or a. c. circuits. They have copper blades and fixed contacts with carbon secondary contacts arranged to open just after the heavy copper contacts. Thus the current is carried by copper parts of ample size when the breaker is closed, and the arcing on opening is largely confined to the carbon contacts which are better for this purpose than metal. Such breakers may become dangerous either from overheating of the coils, from arcing upon opening heavy currents, or from failure to act in emergency as they are intended to do. However, the better types of modern breaker are very well made and form reliable protective devices.

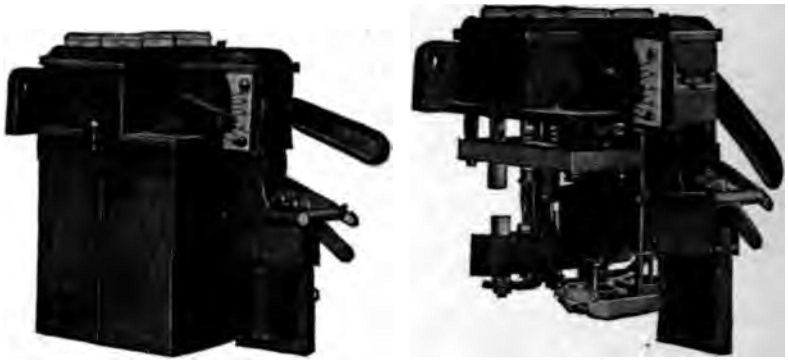


Fig. 147. Modern Oil Circuit Breaker

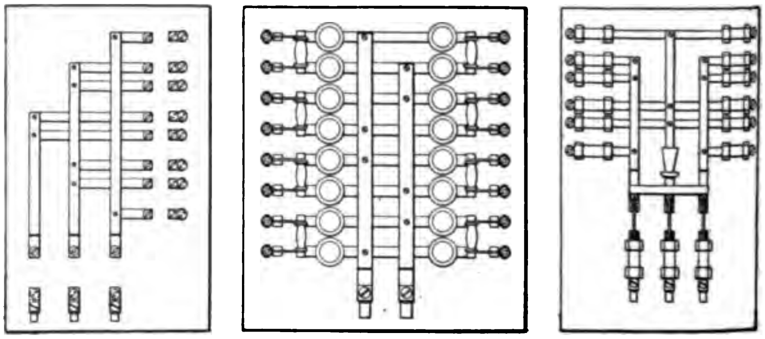


Fig. 148. Typical Panel-Board Bus-Bar Arrangements

Oil-immersed breakers are coming more and more into use. They are made with their contacts immersed in a heavy oil contained in a can or case of suitable form. When the contacts open, the oil aids very greatly in quenching the arc, and such breakers can, therefore, be made quite compact since a long break distance is not so essential. These breakers are made both for switchboards and wall mounting. They are not so well suited to direct-current circuits since the action of the d. c. arc carbonizes the oil too rapidly. Fig. 147 shows a modern oil breaker. They present a hazard due to the oil which may become overheated or even ignited. This is unlikely to occur with a well designed oil switch or breaker, but the usual precautions should be taken to keep the switch and its immediate neighborhood clean and free from accumulations of rubbish or any inflammable material which may become oil soaked.

MISCELLANEOUS DEVICES

Panel Boards and Cabinets. Panel boards are distributing boards, or switchboards from which the branch circuits are led off from the mains. They must have slate bases on which are mounted the necessary bus bars, switches and fuses. A very great variety of panels is made, the arrangement of parts in a few patterns being shown in Fig. 148, while a complete panel set in a steel cabinet is shown in Fig. 149. Fig. 150 shows the wiring channel often provided and a cabinet with wood door and trim. The panel base and the two partitions shown in the section drawing are of slate and all other interior surfaces of the cabinet including the door should be lined with sheet steel.

Wood cabinets should not be used on conduit, armored cables, or metal molding systems of wiring as they do not form a metallic connection between parts of the system and any attempt to overcome this by bonding around the box by wire is not liable to result in a good job. Metal cabinets are preferable in all cases except possibly in very damp locations where they are liable to rust rapidly. All cabinets whether for panels or for individual switches or cut-outs should be thoroughly dust tight and fitted with tightly-closing doors. No metal thinner than No. 16 U. S. Metal Gauge should be used and heavier metal is necessary for all but the smaller sizes of box to secure the requisite stiffness and durability.

Sockets and Receptacles. The almost endless variety of these fittings may be classified in various ways, as for dry or for wet places; key and keyless types; brass shell or porcelain types; conduit boxes; molding signs; miniature and candelabra sockets and receptacles, etc. All standard sockets and receptacles are now made with what are called Edison screw-shells into which the base of the incandescent lamp is screwed, the *shell* being connected in the socket to one of the lead wires and the *center contact* to the other lead wire. In all types the design of the socket or receptacle should be such that when a lamp is inserted there will be no current-carrying part of the lamp base exposed. This calls for a minimum depth of the socket of $\frac{11}{16}$ inch and sockets and receptacles which do not have such depth should not be used. Sockets and receptacles were formerly rated in candle-

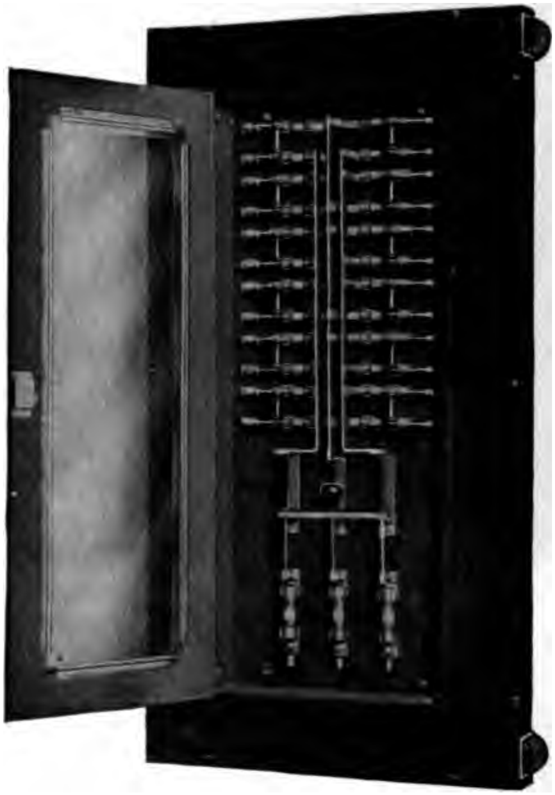


Fig. 149. Complete Panel Board in Steel Cabinet

power of the lamps designed for them or in amperes and volts but the introduction of the newer high-efficiency lamps such as the tungsten and tantalum has rendered this method of rating inapplicable. All key or pull sockets and receptacles of standard types are now rated 250 watts, 250 volts, with a provision that this shall not be interpreted to permit the use at any voltage of current above 2½ amperes.

Keyless sockets and receptacles of standard types are rated 660 watts, 250 volts, but not over 6 amperes at any voltage.

Miniature and candelabra sockets are rated 75 watts, 125 volts.

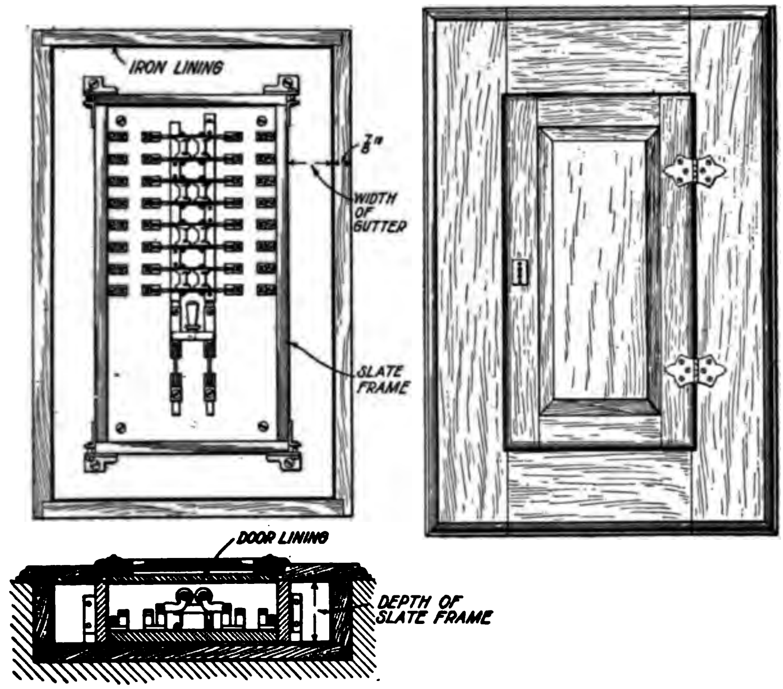


Fig. 150. Panel Board and Wood Cabinet Showing Method of Construction

Weatherproof sockets having no exposed current-carrying parts may be rated 660 watts, 600 volts, and thus may be used in series on 600-volt circuits.

The most common abuse of sockets is to employ them as outlets for currents far in excess of what they or the wiring immediately connected to them should carry and the above limits should be rigidly adhered to. The assigned ratings do not imply that the full power can be taken from each and every socket on a circuit at once. Thus twelve carbon 16 c. p. lamps in sockets may take 6 amperes on a 110-volt circuit and be fused with 6-ampere fuses. At 250 watts per socket, twelve sockets will take 3,000 watts which, at 110 volts, is over 27 amperes, an amount of power forbidden by the rules limiting lighting branch circuits to 660 watts and a current manifestly too large for the No. 14 wire which would usually be used on such a circuit. The ratings 250 watts, 250 volts, for key sockets, and 660 watts, 250 volts, for keyless sockets, are intended to express the maximum safe carrying capacity of each socket or receptacle alone and do not warrant employing them in the manner indicated above, which would seriously overload ordinary circuits.

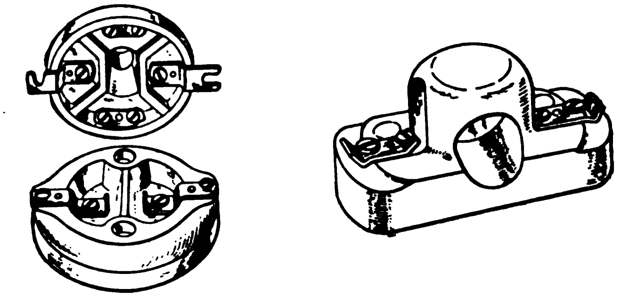


Fig. 151. Common Types of Fused and Unfused Rosettes

Rosettes. These devices are usually of porcelain and provide a means of connecting flexible cords to the main or branch circuits. Types are made either with or without small link fuses in the base but the unfused type is much to be preferred and should be used exclusively in general work since the use of link fuses in porcelain fittings is undesirable because of the possible results following a short-circuit blowing the fuses violently. It is much better to place all fuses at distribution centers, such as panel boards, and by keeping the fuses of proper capacity, depend on them for protection rather than on fuses scattered about in fittings, rosettes, etc. Fig. 151 shows common types of fused and unfused rosettes.

Bell-Ringing Transformers. Within the last few years small transformers have been brought out designed for the purpose of ringing door bells or for other light signaling work, deriving their power for such service directly from alternating-current lighting circuits in houses. They take the form of small, totally enclosed transformers with two very thoroughly insulated coils, the primary coil to be connected directly across an alternating circuit and the secondary to be connected to the bell circuit as shown in Fig. 152.

The push button is, of course, usually open so that no current flows over the bell circuit. When the button is pushed a current of low voltage (10 to 20 volts) and small ampere capacity (not over 2 amperes) flows over the secondary or bell circuit, the power being derived from the primary winding connected to the alternating-current line as in the case of any transformer. Absolutely no dependence can be put upon the insulation of the bell circuit which is often of cotton-covered paraffined wire (annunciator wire) installed in the most unreliable manner and the bells and push buttons are not designed for anything but very low voltage currents. It is, therefore, imperative that the design and construction and insulation of the transformer be such that under no conditions, either of service or from an accident, can the 110-volt current act directly on the bell circuit. Furthermore, the design of the transformer must be such that even if the push button be left closed or the bell wires become short-circuited only a very small current will flow over the bell wiring. In approved bell-ringing transformers both these results are secured with reasonable safety.

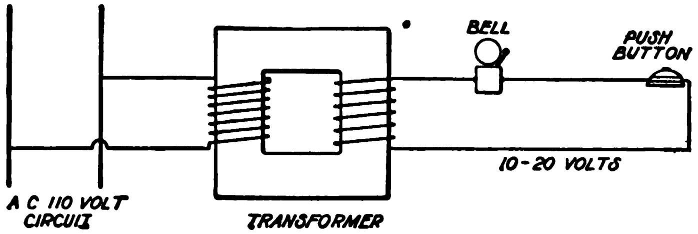


Fig. 152. Diagram of Simple Transformer Circuit

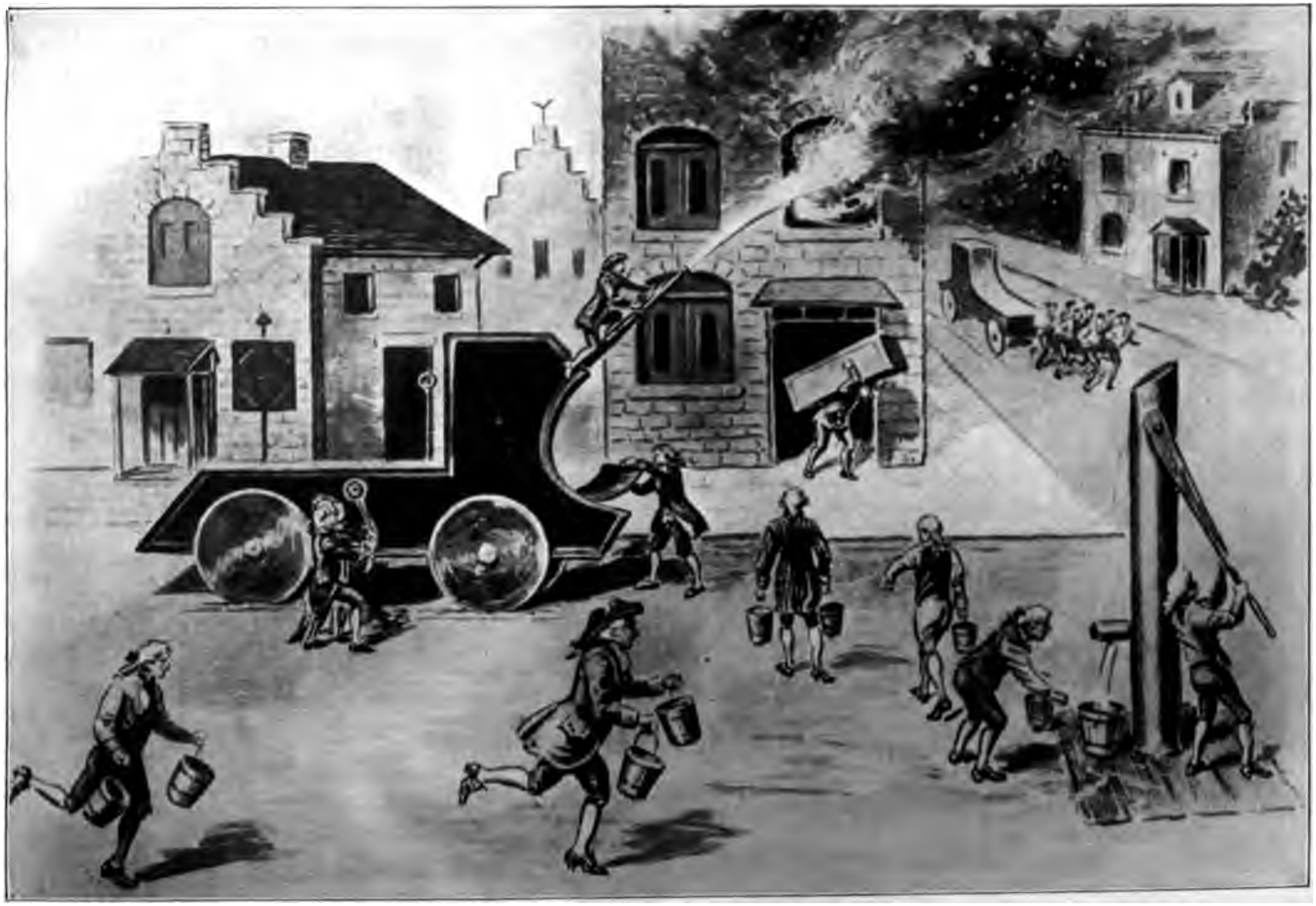
Heating Devices. The rapid introduction of all sorts of electric heating devices for domestic and industrial use has brought with it a special hazard which it is peculiarly difficult to control. These devices are useful only as they are capable of developing a considerable heat in a short time. The normal use, of course, tends to draw away the heat and thus prevent a dangerously high temperature being reached, but if these devices are left connected to the circuit and unused, many of them will reach a dull red heat and may thus become a serious fire hazard. This is true of electric flatirons especially and also of many cooking utensils and other apparatus for domestic or light factory use. It is evident, therefore, that all such heating appliances should be made wholly of non-combustible material and, so far as their use will permit, be fitted with legs, guards, or other parts which will keep the heated parts well separated from walls, floors, tables, etc.

Stationary heating devices should be installed only when every precaution has been taken and the fact that perhaps only a low temperature will be produced by the proper and normal operation of the heater should not be made an excuse for omitting any of the precautions that would be taken for the higher temperatures which may easily result from accident or misuse. There should be ample air spaces and proper protection of adjacent surfaces by asbestos board and metal sheathing. •In general all electric heating devices must be installed and used as possible sources of great heat.

Portable heating devices are not easily protected from misuse or accident. The chief protection against fires from such appliances appears to depend upon the original excellence of design and construction of the devices themselves, the fact that many of them employ but a small amount of energy, and, finally, upon a slowly growing appreciation by users and the public generally, that electrically-heated appliances, while usually fairly safe, if properly used, may very readily become dangerous if abused or improperly used.

Electric Gas Lighters. A battery, spark coil, and similar appliances are often used for the purpose of lighting the gas on gas fixtures without the use of matches. In such installations the wires from the battery and coil are led to the fixtures in any convenient manner and on the fixtures themselves small wires are carried down the outside of fixture stems and arms to the burners. The line wires are not insulated or installed in a manner comparable as to safety with electric light wires, and on the fixtures the insulation is especially weak and exposed to injury. It is, therefore, evident that such gas-lighting systems should never be installed on the same fixture with electric lights, since a breakdown is very liable to permit the electric-light current to pass over the gas-lighting wires and cause a fire at some point perhaps concealed in a partition, either from overheating the small wires or from arcing to other wires or to grounded metal piping.

Marine Work. The Code contains special rules governing the installation of electric light and power wires and apparatus on shipboard. These differ from the standard rules in only a few particulars, as indicated by the need of special care to provide against the effects of constant and severe vibration, dampness and extreme hard usage to which marine installations are always subjected. The provisions of the Code should be referred to in detail by those who are called upon to install or inspect work of this special type.



COPY OF OLD PRINT REPRESENTING FIRE-FIGHTING METHODS IN NEW YORK IN 1730

ELEMENTS OF FIRE INSURANCE

FIRE INSURANCE AS AN INSTITUTION

Introduction. Fire Insurance may be considered as two separate and distinct things: (1) a practice or custom followed by property owners; and (2) an established business or commercial enterprise. Although the latter is a result of the former, the treatment of the subject of Fire Insurance will be simplified by considering it from these two standpoints.

Protection to Property Owners. Fire Insurance exists because of the natural desire of men to protect themselves against bad or unfavorable results due to risks, happenings, events, or accidents which they can neither prevent nor control. It is a means of protection against a loss of money, and is obtained by purchasing a promise or a guarantee from certain parties that they will make good the amount of any loss or damage as a result of a fire.

Business Enterprise. Fire Insurance as a business enterprise consists in selling promises or guarantees against loss by fire. The persons engaged in Fire Insurance as a business, deal in these promises or guarantees precisely as other persons deal in merchandise or anything that people want and are willing to pay for; there is a seller and a buyer, an article or commodity to change hands, a price for the article, value received for the buyer, cash or money and a profit on the transaction for the seller.

Thus it may be seen that Fire Insurance is the buying and selling of guarantees against the loss of money caused by the destruction or the damage to property by fire.

Definitions. In order to make clear to the layman certain technical terms used in Fire Insurance, the following definitions are given:

Insured. The buyer of Fire Insurance is called the *insured* or the ***assured.***

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Insurer. The seller of Fire Insurance is called the *insurer* or the *assurer.* Sometimes *underwriter* is used. (This word has a special meaning which will be explained further on.)

Indemnity. The article that is sold, *i. e.*, the insurance, is called *indemnity*, and is a bond or guarantee to make good, to pay for, or to satisfy a loss, damage, or injury.

Policy. The bond or guarantee when placed on paper is called a *policy*, and is the proof and evidence that the insurance has been bought and sold as a regular transaction.

Rate. The price of Fire Insurance, *i. e.*, the cost for each $100 of insurance, is called the *rate of premium*, or, briefly, the *rate.*

Premium. The cost of Fire Insurance, *i. e.*, the amount of money paid for the total amount of insurance, is called the *premium.* The premium is the insurer's reward or compensation for the risk that he takes in guaranteeing or promising to pay the property owner in case of loss by fire.

Early Fire Insurance. Previous to the great fire of London, history records a few forms of Fire Insurance. In Assyria and the East, more than 2,500 years ago, some protection against fire was made in connection with the communities of towns and districts. Judges, priests, and magistrates were appointed for each town and district with power to levy contributions from each member of the community, to provide a fund against calamities, such as drought and fire. If the judges were satisfied that a fire was accidental, they empowered the magistrates to assess the members of the community either in money or in kind, and in the event of any member being unable, through poverty, to meet his share of the contribution, the deficiency was made up from the common fund.

About 1240 A.D. the laws of Count Thomas of Flanders provided that the members of a community, as a whole, should make good a loss which fire might cause to an individual, unless the incendiary who caused the fire could be discovered, in which case the loss was to be made good from his property and he was to be banished.

During the middle ages when Guilds existed among the Anglo-Saxons and Germans, Fire Insurance was provided as one of the benefits from a common relief fund established by regular contributions as a protection and security against losses by fire, water, robbery, or other calamities.

In 1609, a plan was suggested to the Count Von Oldenberg whereby he personally, upon an annual payment to him of a fee or premium of $1 for every $100 of valuation, should insure those of his subjects who might desire it, against the loss of their houses by fire. The plan appears not to have been adopted by the Count, who thereby lost the opportunity to become the first individual insurer as well as the founder of Fire Insurance.

Insurance in general had its origin in the uncertainties of sending goods or property over the sea in ships. Ships and their cargoes were subject to many perils, such as storms, collisions, fogs, pirates, and wrecks; and the loss of the goods or the ship itself could cause the financial failure of the merchant or the ship owner. Insurance of ships and their cargoes provided beforehand for the dangers or results of the voyage and thereby strengthened the merchants and ship owners in carrying on their business. It permitted them to do business on a larger scale and in more distant parts of the world than they otherwise could do if they had no protection against financial loss.

The insurance of property at the risk of the sea proved to be a good practice and a distinct benefit to commerce and trade by water, so that in time it was adopted for property on land. This adoption was perhaps hastened by a calamity, for Fire Insurance is supposed to have been started as a result of the great fire of London in 1666. This fire burned for four days and nights and spread over 436 acres of territory. Over 85 per cent of the buildings in London were destroyed, while the property loss was estimated to have been about 10,000,000 pounds sterling—a sum which today would be nearly equal to $300,000,000. There was no Fire Insurance at the time, so the fire proved a tremendous loss to the citizens of London, and the city did not recover from the effects of it for a number of years.

Immediately after the fire, various plans were instituted for the protection of property owners against a similar loss. In 1667, Nicholas Barbon opened an office and proposed to insure houses and buildings. Barbon was, therefore, probably the founder of modern Fire Insurance, as he was the first man to be prominently identified with it, and his methods of transacting business were virtually the methods that are followed today. Fire Insurance as practiced by Barbon was limited to houses and buildings.

Insurance of Goods. In 1706, Charles Povey opened an office in London for the insurance of goods and stocks of merchandise. Povey offered Fire Insurance without backing or financial support and merely gave his promise to pay in the event of a loss. His venture was greeted with ridicule, and his proposal to insure personal property was generally considered impractical. After three attempts he succeeded in organizing, in 1710, what is today known as the Sun Fire Insurance Company. It is the oldest Non-Mutual Fire Insurance Company in existence as well as the first Fire Insurance Company which undertook the insurance of moveable goods or personal property. It was organized as a partnership, and has continued as such, it being almost unique among insurance companies in this respect.

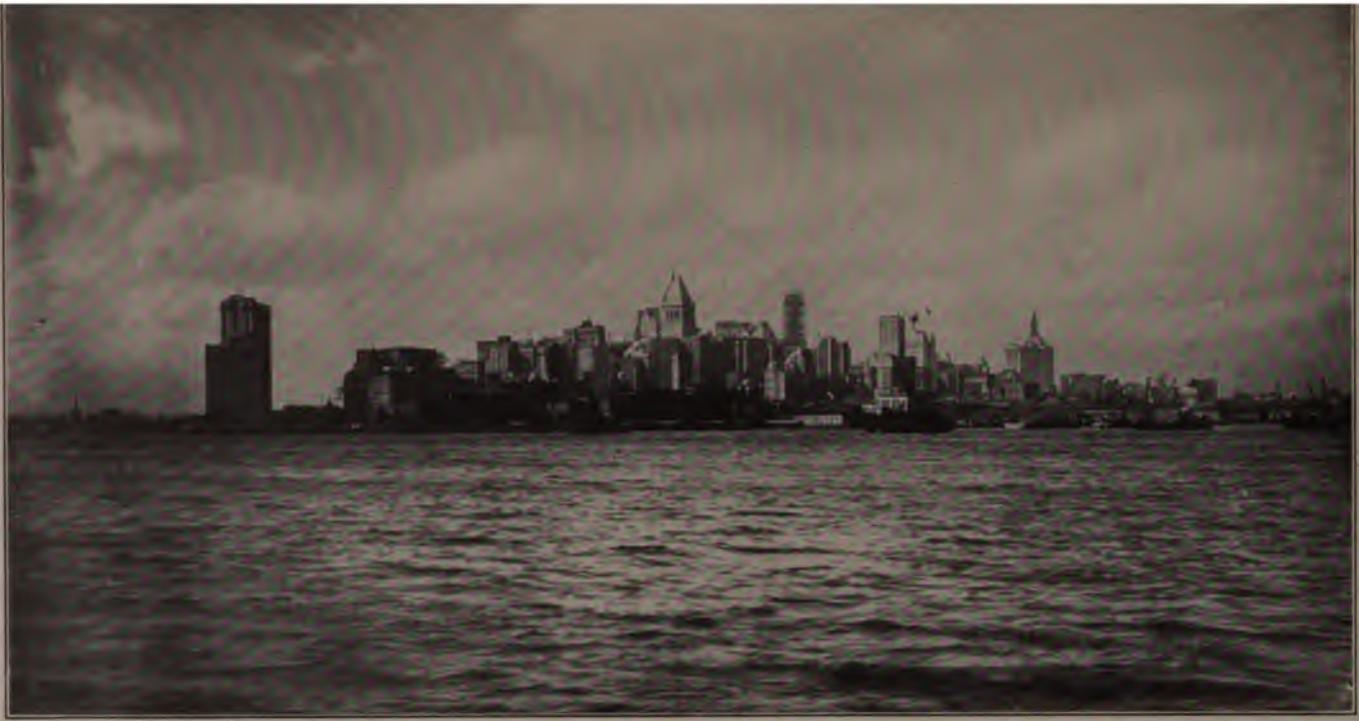
Fire Insurance by Corporations. The first Fire Insurance corporation originated in 1720. The Royal Exchange Assurance Company and the London Assurance Corporation were granted charters to do a marine insurance business and in the following year were also authorized to transact Fire and Life Insurance.

Principles of Fire Insurance. During the growth of this important institution there have been formulated certain fundamental laws or established rules to which all questions and problems are referred in order to ascertain the true purposes of Fire Insurance and how it should be properly accomplished.

Fire Insurance insures against the peril, danger, or risk of fire.
Fire Insurance insures against a loss.
Fire Insurance insures money value.
Fire Insurance insures the owner of property.

(1) *Risk.* Fire Insurance insures against *fire* only, and this limits its application to the risk or result of fire and to no other risk or result. Any claim or demand on Fire Insurance must have as its starting point the occurrence of fire and must proceed from the direct result of fire or arise from the effects of fire.

(2) *Loss.* Fire Insurance insures against a *loss* and this limits its application to real and actual loss. Any claim or demand on Fire Insurance cannot originate or hold unless there be a loss. Fire Insurance cannot be used to obtain a profit for the property owner and any payment under Fire Insurance must not be for anything but a loss and it cannot go beyond a loss.



NEW SKY LINE OF NEW YORK CITY

The View Shows the Woolworth and New Municipal Buildings in the Course of Construction. Singer Tower Is Just Back of the Pyramid Tower of the New Bankers Trust Building in the Center of the Picture

[illegible] NEW YORK
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(3) *Money Value.* Fire Insurance insures *money value* and this limits its application to the destruction of material value. Material value is defined as *that value which can be measured in money or other commodities.* It is sometimes called the *fair cash market value* of the property affected by the fire, or a value that can be restored. It is one of the purposes of Fire Insurance to restore things as they were, and if the property is such that it cannot be restored, then its value is not material, but *sentimental;* in this case no claim can be made on Fire Insurance, for Fire Insurance is a part of the material world only.

(4) *Ownership.* Fire Insurance insures the *owner of property* and this limits its application to the person, not the thing. Any claim or demand on Fire Insurance must proceed from a human being or person in the eyes of the law. Fire Insurance is an agreement with a person, who is the *owner of property,* to insure *not the property,* but *the owner's interest in the property.*

Summary. The four fundamental principles of Fire Insurance may be summed up in one statement or proposition as follows: *Fire Insurance is a promise to pay the owner of property a loss of money when this money is represented by property which has been damaged or destroyed by Fire.*

Functions of Fire Insurance. *Protection.* Fire Insurance is a transaction of world-wide custom and application, and, therefore, has a relation to the public as a whole; it may be said to have the public function of protecting the people against fire as a destroyer of money value. The people need this protection against fire because it is an event or calamity which is not included in the plan or method by which people work; it strikes an individual or group of individuals a blow which they are unable to withstand alone. They must look to other individuals or communities for the assistance which they themselves would give if conditions were reversed. As a result, all individuals and all communities agree to bear the effects of these calamities as a common burden, making them a practical application of the idea of common, mutual, or reciprocal interest.

Restoring of Property Loss. Fire, by causing the destruction of money value, deprives an individual or group of individuals of their working capital—*i. e.,* the means by which they exist and do business—and makes it necessary, as a matter of public safety, to provide means for restoring the capital which has been destroyed

This reimbursement for property loss becomes, then, the chief function of Fire Insurance.

Fire Insurance is a great aid to business and enterprise of every description; it is one of the principal bases of financial credit; and it is a great factor in the widely extended use of capital, which is a feature of the mercantile and manufacturing operations of the modern world. For example, the mercantile and manufacturing establishments of the present day often accumulate destructible property to the value of a million dollars or more under one roof, and thereby assume a risk which they could not afford to take if they had no financial protection in case of fire. Fire Insurance, therefore, guarantees the permanence or stability of the business and permits its operation on a scale and to an extent that would otherwise be impossible. It permits a business man to invest on as large a scale as his financial resources will allow, for he knows that he is protected against loss by fire. It permits a business man to borrow sums beyond his own capital, for capitalists do not hesitate to loan money on buildings which are protected by proper Fire Insurance. Furthermore, it permits manufacturers to sell goods to dealers on a credit of three or four months' time, because the goods are protected by Fire Insurance, and, if destroyed by fire, the dealer will still be able to pay the manufacturer.

Fire Insurance is an aid to communities as well as to individuals, as shown by comparing the slow recovery of London from its great fire, at a time when Fire Insurance was not practiced, with the wonderful reproduction of Chicago in 1871, the substantial and rapid restoration of Boston in 1873, and the rebuilding of Baltimore in 1904 and San Francisco in 1906—all largely due to the payment of the Fire Insurance indemnity.

Fire Insurance a Tax. Fire Insurance may be considered a process of assessing, collecting, and distributing a fire tax sufficient to make good the money loss caused by fire. This is done through the sale of Fire Insurance policies just as the government collects various taxes by the sale of postage and revenue stamps.

Fire Insurance fixes the amount of the assessment by a graded tariff or differential list of charges, which measures or estimates the chance of loss and establishes a specific rate or price for insuring properties according to their liability of loss or damage by fire. These tariffs which have been established as a result of the world's fire experience and which are based on statistical averages founded upon time, space, and numbers, have been prepared by associations of companies existent among Fire Insurers for many generations. The fire tariff associations measure the degree of unlikeness in properties or risks and this unlikeness is analyzed, weighed, and valued in order to make like rates for like risks and unlike rates for unlike risks.

Fire Insurance Policy. The *policy,* as already defined, is the bond or guarantee issued by the company as proof that a certain amount of insurance has been bought and sold. The issuance of the policy puts the insurance in force and makes it a thing of real and actual value to the property owner. It gives the Fire Insurance a legal standing and establishes a legal contract.

The policy in external form and shape is a large sheet of printed paper with some portions left blank where certain details are to be filled in in writing. Additions or corrections to the policy are also made in writing, while the signatures are either in writing or in printed facsimiles of writing.

Form. The form of policy of the present day has been in use without change almost from the beginning of Fire Insurance. It is a sheet of paper 17 inches wide by 21 inches long, and is folded twelve times, so that when closed, and first presented to a person, it is a folded paper 3¼ inches wide by 8½ inches long.

The face of the folded policy has the following printed information: (1) That the policy is the standard or legal policy of certain states; (2) Date that the policy expires and ceases to be of value; (3) Location of the property insured; (4) Amount of the insurance; (5) Amount of the premium; (6) Name of the insured; (7) Serial number of the policy as contained in the records of the insurer; (8) Name of the insurer or company and the amount of its capital or surplus; (9) Address or location where losses are paid; and (10) Notice or warning that the written portions of all policies covering the same property should read alike.

The policy, when opened to one quarter of its size, exhibits the names of the officers of the company and the following three important clauses or endorsements: (*a*) Form for assignment of interest by the insured; (*b*) Form for consent by the company to the assignment of interest; and (*c*) Form for the receipt of returned premium and the surrender of the policy by the insured.

The policy matter is divided roughly into three divisions, viz, details of the transaction or indemnity; details of the property and special conditions; and standard or legal clauses and conditions required by law in all policies.

An itemized or enumerated list of the things contained in a policy in the order in which they appear is as follows: (1) Character of insurer—for example, Stock Company; (2) Serial number of policy as contained in insurer's records; (3) Amount of insurance in figures; (4) Rate of premium; (5) Title of insurer and address (residence or location); (6) Statement of consideration, *i. e.*, (*a*) stipulations named, and (*b*) cash or money as premium; (7) Clause binding the insurer, *i. e.*, the words *does insure* or *do insure;* (8) Name of insured or owner; (9) Term of policy or length of time during which insurance is good; (10) Date of day, month, year, and hour of day that the insurance begins and ends; (11) Risk, peril, danger, event, damage, or loss, against which the insured is protected; (12) The amount of insurance written in words; (13) Clause limiting the insurance to the property described in the following blank space or lines, or in a sheet of paper attached to the blank space.

This sheet of paper attached to the blank space, called the *form*, is a separate sheet of paper simply as a matter of convenience, because it has been found easier in practice to have all matters that go into a form placed on a loose sheet of paper rather than printed or written in the blank space left on the policy. Any paper attached to the policy in this manner has the same force and value as if it were a part of the policy itself.

It is customary to include in the *form* the following important things: (14) Specified parts or amounts of the insurance, if the total sum is divided; (15) Specified and detailed description of the property insured; (16) Location of the property insured; (17) All special clauses, which are part of or belong to the particular policy, including privileges or permissions granted by the insurer, warranties or agreements made by the insured, and also any other feature which is not an established or fundamental part of the policy, as ordered by the law according to the printed lines underneath the blank space.

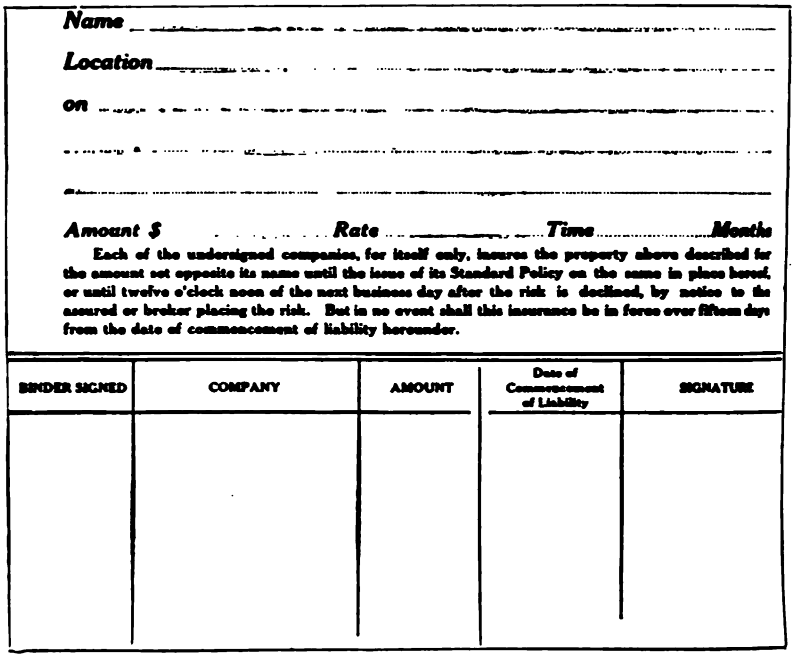
The balance of the policy consists of: (18) Conditions, stipulations, and provisions established by the State and required by the Law in all policies issued by insurers, which are contained in what is called the *printed portion* of the policy as distinguished from what might be added to the policy in the form, and which include the lines numbered from 1 to 112; (19) Paragraph, treating of conditions governing waiver of policy provisions; (20) Date that policy has been executed or subscribed by agents or officers; (21) Subscription or signature of officers of company; (22) Counter subscription or counter signature by agent of company, if policy is issued by such.

FIRE INSURANCE AS A TRANSACTION

Fire Insurance as a transaction is begun by a property owner applying to a Fire Insurance Company for insurance. The various steps in the transaction are as follows: (1) Application for Fire Insurance by a property owner; (2) Temporary insurance granted by the Insurer; (3) Inspection of the property by the Insurer; (4) Making of a rate of premium or fixing the price of the Fire Insurance; (5) Approval of the risk or the decision to insure or not to insure; (6) Writing of the policy; (7) Payment of the premium or cost of the insurance; (8) Occurrence of a fire; (9) Settlement of the claim and adjustment of the loss.

Application for Fire Insurance. The application for Fire Insurance made by a property owner to an Insurer or Fire Insurance Company consists of a request for insurance together with name of property owner, location and nature of property, and amount of insurance desired. The application, which is treated practically as a memorandum in order to allow the insurer time to look into the matter, is frequently made orally and by a representative or agent of the property owner to a representative or agent of the insurer.

Temporary Insurance. When Fire Insurance is applied for, the applicant is usually given a paper called a *binder-policy.* However, in many cases a binder is not given to the applicant, but the insurance may still be legally in force, because the law recognizes the validity and legality of Fire Insurance which has not been confirmed by the making of papers as records and proofs. The binder is just as much a policy as the completed document, serving the purpose of giving the applicant for insurance immediate protection as well as allowing the Fire Insurance Company sufficient time to investigate the conditions of the risk before definitely and permanently issuing the insurance. The form of binder in use in New York City and approved by New York State is shown in Fig. 1.



Name

Location

on

Amount $ ***Rate*** ***Time*** ***Months***

Each of the undersigned companies, for itself only, insures the property above described for the amount set opposite its name until the issue of its Standard Policy on the same in place hereof, or until twelve o'clock noon of the next business day after the risk is declined, by notice to the assured or broker placing the risk. But in no event shall this insurance be in force over fifteen days from the date of commencement of liability hereunder.

BINDER SIGNED	COMPANY	AMOUNT	Date of Commencement of Liability	SIGNATURE

Fig. 1. Form of Binder Used in New York City

Inspection of Property. The Fire Insurance Company inspects the property offered for insurance for the general purpose of collecting such information as will enable it (1) to decide intelligently and efficiently whether it is desirable to furnish the insurance, and (2) to issue or write the insurance in such a form as to give the property owner the protection or indemnity that he desires.

The information concerning the property offered for insurance is specialized according to the requirements of the different branches of the company. The *rating department* needs information about the features of the property which may have a bearing on the *rate.* The *underwriting department* needs information which will enable it to judge the desirability of the risk as well as the amount of insurance that can be safely issued on the property. The *policy-writing department* needs information to enable it to issue the policy in correct form and to state all the details of the property in order to give the owner the protection he is seeking as well as to protect the company by the terms and conditions under which the insurance is issued. The *loss department* needs information that will assist it to appraise the damage caused by fire and in this respect it is frequently dependent entirely on the records of the inspection report, because all other evidence may have been destroyed by the fire.

Rating a Property. The *rating* of a property offered for insurance is exactly like fixing the selling price of an article of merchandise. The rate is made by a *rater* or *rate clerk* who is generally furnished with certain tables or lists of rates which have been established or determined for different classes of properties and for different localities as the result of practice and experience. A particular class of building or business, therefore, when located in a particular city, town, village, or other situation will be found to have a fixed *base* or *class rate*.

The rater examines the inspection report and from the information furnished therein classifies the property and gives it its base or class rate. If the property is of the kind for which class rates have been established and it does not vary from the average or typical property of its class, the making of a rate is simply the work of assigning the property to its right class and taking the proper rate figure. If the property, however, is such that it cannot be rated as a class property, but must be given a special or individual rate, because of its particular conditions, then the rater must make up an *itemized* or *scheduled rate* on the property.

In the making of an itemized rate, the class rate set for the building or business is taken as the base or foundation of the rate. To this *base rate,* the rater adds charges or additions for the bad features of the property, and, correspondingly, deducts amounts or allowances for the good features. In this process of itemized rating are considered: construction of the building and its defects and improvements; special hazards (causes of fire) connected with the business or occupancy; fire protection systems and appliances; exposure or fire danger from outside sources; and general conditions arising from management of property

The above features, on close inspection and analysis, would themselves subdivide into a number of small individual features, each of which might call for a charge or increase in the rate, or, on the other hand, might call for an allowance or reduction depending on whether the feature was a defect or a benefit.

Approval of Risk. Fire Insurance Companies do not insure all properties that are offered to them for insurance. The process or method by which properties are selected, is in its narrow, technical sense called *underwriting*, and is practically a system of judging insurable properties, the underwriter being the judge.

In the decision to insure or not to insure, the underwriter considers the following things: rate and premium; physical hazards of the property; moral hazards; experience of the class of property; liability limit; and percentage of expected loss.

The work of the underwriter is difficult of explanation, because there are few, if any, set rules or methods in this branch of insurance. It is, to a large extent, a matter of feeling or instinct and an underwriter frequently accepts or declines insurance without explanation for his actions.

Writing the Policy. A Fire Insurance transaction amounts to a legal contract and, as it is customary to have legal contracts drawn up in writing and in a set form, the Fire Insurance contract is represented by the policy. The policy is prepared or written from the information contained in the application made by the property owner, the inspector's report, the rater's report, and the underwriter's report. The writing of a policy has two phases: one, *ordinary*, or *clerical;* the other, *special*, or *legal*. The ordinary work of writing a policy is almost entirely a clerical matter and requires little more than a correct transcription of details contained in the various reports. The special or legal part of policy writing is the attaching of warranties and clauses, and the preparation, or examination and scrutiny, of the *form*.

The insurance company depends on its policy writer to do two things: (1) to see that the policy makes the company liable only for what the insurer has contracted for; and (2) to see that the policy holds the property owner or insured to the carrying out of conditions or agreements that are a part of his application for insurance, and on which the insurer has fixed the rate and has guaranteed the indemnity or financial protection. After the policy has been written, it is signed by the insurer, usually the President and the Secretary of the company, and then is countersigned by the agent of the company, if the policy is issued by such.

Payment of the Premium. When a policy is delivered to the insured or property owner, the insurance company has furnished the guarantee or promise of indemnity, and the payment therefor is due. A bill is sent with the policy and the money is supposed to change hands on the basis of a cash transaction. In practice, however, credit is generally granted and payment is postponed or deferred for a given period, such as ten or thirty days, during which time the holding of the policy keeps the insurance good, but at its expiration, if the money is not paid, the insurance company may withdraw the insurance by giving five days' notice to the holder of the policy and at the end of the five days the policy ceases to be of any value.

Occurrence of Fire. As the entire Fire Insurance transaction deals with fire, it need hardly be said that it takes a fire to make a loss and thereby to cause a demand on the insurance company to make good its guarantee. When a property owner carrying Fire Insurance suffers a loss by fire, he must do two things at once: send a written notice to the insurance company, and protect the damaged property.

The sending of a written notice consists of an ordinary letter, which states that there has been a fire on a given date at a given location, and that loss has been caused to property insured by a policy of the insurance company.

The protection of the damaged property consists in stopping further damage or in stopping unnecessary damage to other property which is uninjured. This is usually done by separating damaged from undamaged property, stopping water from flowing and leaking, and doing anything else that common sense suggests to prevent the loss from increasing; in other words the property owner should act as if he had as much interest as the insurance company.

After this has been done, the property owner is required to make an inventory of the personal property, stating the quantity of each article, the cost of it, and the amount of loss claimed on it. These preliminary steps are required to be done at once. In addition a *sworn claim* or *proof of loss* must be made to the insurer within sixty days. This proof of loss contains the following features: (*a*)

Knowledge and belief as to origin of fire; (*b*) Interest of parties in property; (*c*) Value of, and loss on, *each item;* (*d*) Incumbrances; (*e*) Other insurance; (*f*) Copies of policy forms and descriptions; (*g*) Changes in *title, use, occupation, location, possession,* or *exposure;* (*h*) Occupancy of buildings; (*i*) (If required), Plans and specifications of buildings or machinery; and (*j*) (If required), Magistrate's certificate.

Settlement of Claim and Adjustment of Loss. When an insurer or insurance company has been notified of a fire, which has caused damage or loss to property insured under one of their policies, the matter is put in charge of an *adjuster.* An adjuster is an insurance company's representative who investigates fire, examines claims for loss, and certifies the payment of money as the indemnity guaranteed by the policy.

The adjuster's work falls into three parts: investigation; adjustment; and verification of liability. The investigation of a fire or loss is the preliminary step taken by the insurance company to protect its interests, as they are not required under any circumstances to pay losses caused by dishonest or malicious fires. The adjuster collects all the facts he can regarding the origin and the spread of the fire; he examines the policies held by the property owners and takes what steps he considers necessary to protect or save the damaged property.

Value and Loss. The adjustment consists in finding the real and the actual amount of the loss or damage. The first thing sought is the *value of the property;* the second, the *amount of the loss,* the two being usually determined either by agreement or appraisal.

By the agreement method the insurer and the insured accept estimates made by their representatives or experts. If the value and the loss cannot be agreed upon by making estimates acceptable to both sides, then the matter is settled by appraisal.

In an appraisal of a Fire Insurance loss, the property owner and the insurance company each select an appraiser to represent them, and these two select a third appraiser, who is in reality an umpire or judge, because he is expected to decide impartially and without prejudice or favoritism to either party. The appraisers consider all the facts in the case and make a decision which determines the amount of the loss.

Salvage. In the process of adjustment, it frequently happens that the damaged property must be handled or *salvaged.* Salvage is the work of preventing further damage, and consists in separating the property affected by the fire—undamaged property being placed by itself, more or less damaged property in another place, and the totally destroyed or worthless stuff put aside so that it does not continue to injure property that can be used or sold. The work consists in reducing the actual loss or damage from fire to a minimum and is often done in behalf of both the property owner and the insurance company, but usually by the insurance company.

Liability. After the amount of the loss has been determined, the adjuster then considers the question of liability for his company, *i. e.*, is the insurer bound to pay the loss, and, if so, how much or what part of the amount? In some instances the facts or circumstances of the fire are such that the insurance company has been released from its liability or promise to pay. This can happen in various ways: The policy can be voided or forfeited by some act or neglect of the property owner; the fire may have been caused by something that the policy contract excludes as a proper cause for loss; or the property suffering a loss may not be included in the property described by the policy. In case the insurance company is liable the next question is: To what extent? A reduced or partial liability for the insurance company may result in several ways.

First, in case the insurance company is the only insurer, and, therefore, has all the liability that exists, then it can result that this insurer is not bound to pay the full loss because the property owner failed to carry as much insurance as he agreed to carry. This is a condition in the policy, which is called the *co-insurance clause,* and when it is not observed by the property owner, the insurance company is required to pay only a percentage of the loss instead of the full amount.

Second, in case there are several insurers, partial or reduced liability can result for all the insurers, because the property owner has not observed the co-insurance clause, and, therefore, must assume a part of his own loss instead of the insurers paying it in full.

Third, when there are insurers, partial liability results for all, because each insurer is required to pay a loss in accordance with the portion of insurance that he issued. That is, each insurer or insurance company pays the same percentage of the amount of the loss as they hold of the amount of the insurance. This is what is called the *pro-rata* or *contribution clause.*

Settlement. After these various questions—value of property, amount of loss, percentage of liability—have been settled and the net amount of the loss determined or ascertained, the insurer or insurance company can settle the claim or make good the loss in several ways: It can rebuild the structure, if it is a building; it can repair or replace the property as it was before the fire; it can pay the amount agreed upon as the value of the property, *i. e.*, buy it as a regular sale; or it can pay cash to the amount of the loss or claim. The last method is the one generally followed, but the others are sometimes used.

FIRE INSURANCE AS A BUSINESS

The Fire Insurance business is conducted by four classes of business concerns:

(1) *Joint-Stock Corporations or Companies.* The Joint-Stock Companies are the largest and transact the greatest part of the insurance business, and for this reason they are considered as *regular* Fire Insurance companies, while all others are considered *special* companies.

(2) *Mutual Corporations or Companies.* The Mutual Companies, although most numerous, operate principally in rural communities. An exception to this, of course, is the Manufacturers' Mutual Companies, which are so well established in manufacturing centers that they are really as well known as the Joint-Stock Companies.

(3) *Reciprocal Underwriters or Inter-Insurers.* Reciprocal Underwriters or Inter-Insurers are a development from the Mutual Insurance idea, in that they do business only with their own members and are organized for the purpose of getting Fire Insurance at cost. They are organized only among certain large trades, principally mercantile establishments, and accordingly are found only in the large cities.

(4) *Lloyds or Individual Insurers.* Lloyds or Individual Insurers are simply single persons or groups of persons who transact Fire Insurance on their individual responsibility and on a proprietorship basis.

JOINT-STOCK FIRE INSURANCE COMPANY

Corporation. While the nature of a corporation, of which a Joint-Stock Fire Insurance Company is an example, is nowadays understood, it may be worth while to explain briefly how it is formed and how its relations in the world of business are carried on.

In order to understand the workings of a corporation, it must be remembered that business can be transacted only by persons or bodies, for only persons or bodies can be held responsible for their actions. If business could be carried on only by human beings, it would mean that business must be done under the form of an individual ownership or of copartner ownership. That is to say, one man must carry on a business himself, or he must join with other men as partners, and all share in the investments, expenses, profits, debts, liabilities, and other responsibilities of a business.

There are serious objections to the partner arrangement, because any one of the partners, individually or separately, can be held liable for all the debts or responsibilities of the business, *i. e.*, there is no limit to the liability of any one man engaged in a business partnership, a legal circumstance that has frequently resulted in hardship and financial loss to many an innocent man. It was to provide a way of avoiding this unlimited liability in business arrangements that the law permitted the formation of corporations; which, while being managed by natural persons, really consisted of artificial persons created by law, or under the authority of law, with powers and liabilities separate and distinct from the persons or members who compose the corporation.

In this way a number of persons can form a company, society, or association which is a "body" of persons in the eyes of the law; that is, it is lawfully incorporated. It has the advantage of a partnership, in that a number of men can combine to carry on a business, while it is without the disadvantage of a partnership in that the responsibility or liability of the members is limited only to the amount of money or the share taken by them in the corporation.

A Joint-Stock Fire Insurance Company is, therefore, a corporation formed by a number of persons, who have invested money in it as capital, and for this money have received certificates of stock, or shares, in proportion to the amount of money they put in. These investors are called *stockholders*, and are collectively the proprietors or owners of the corporation. They have invested their money with the expectation of financial returns, so that the company is established and conducted, like any other business enterprise, for the purpose of making money by selling Fire Insurance at a profit.

The company is managed by its officers, subject to the control of the directors and the stockholders. The officers, if not practical men, employ such men to carry on the strictly insurance work of the company, while they attend to the general business activities. The companies usually do a general Fire Insurance business, operating in all parts of the country or the world, insuring all classes of properties, and offering policies of insurance at a stated price. The policies of insurance are covered or made good by all the assets of the company, *i. e.*, the liability assumed under the policies, or, to state it another way, the *loss-paying ability* of the company is represented by the capital, surplus, undivided profits, and all other property of the company.

THE MUTUAL FIRE INSURANCE COMPANY

Mutual Fire Insurance Companies are in most cases simply associations of individuals who have offered to insure one another on a mutual or co-operative plan. Such companies are sometimes regularly incorporated, but, as a rule, the form of organization is that of an association or society, for the reason that all the operations are confined to the members and responsibility to outsiders is seldom incurred.

To form a Mutual Fire Insurance Company, it is only necessary for a number of individuals to sign an agreement and to elect officers or directors to manage the company's affairs. The officers or directors, if they are not practical insurance men, employ men to do the technical insurance work of inspecting buildings, making rates, issuing policies, collecting premiums, and adjusting losses.

In the working of the simpler and locally managed Mutual Companies, practically nothing is done beyond the signing of the agreement until a fire occurs and one of the members suffers a loss. Then it is necessary to apportion the loss among all the members and collect from each the amount that he should pay, this sum being in proportion to the amount of insurance that he carries. It is the Mutual principle that the benefits and the losses shall be shared by all the members on the basis of the amount to which they participate; that is, a member pays such a proportion of a loss as his own insurance is of the total insurance. For example: A member with $10,000 insurance out of a total insurance of $1,000,000 is receiving 1/100 of the benefits of the company and he should, therefore, pay 1/100 part of any loss. This is the *pro-rata* principle.

Some Mutual Insurance Companies follow the Joint-Stock Company method in-so-far as they collect premiums from their members and pay losses from the premiums whenever possible. However, in the Mutual Companies, it is customary for only a portion of the premium to be paid in cash, the balance being covered by promissory notes, which are called upon when assessments must be made for the losses beyond the amount raised by the cash premiums.

For example: Mutual Insurance policies are usually written for five or seven years, but only one year's premium will be paid in cash and the promissory notes for the remaining premiums are a lien on the property insured by the member making the note. In some cases the promissory notes are considered *deposit notes* and are made for several times the amount of a member's premiums in order to furnish the company with a proper working fund.

As it is a part of the Mutual Insurance Company plan to assess the members in case of losses beyond the premium receipts, so it is also the plan to return dividends to the members when the losses are less than the premium receipts. This has been the case of the New England Manufacturers' Mutual Fire Insurance Companies, which have been so well conducted that they deserve special study in order to dissociate their operations from those of Mutual Insurance Companies as a whole, which have bad reputations because of their mismanagement and failures.

These Mill Mutual Companies, as they are popularly called, belong to a group or association called the *Associated Factory Mutual Fire Insurance Companies*, with headquarters in Boston, Mass. These companies are established in the various New England States, but also have members in other manufacturing States. They have been so successful for a long period that they have been enabled to do away with the necessity of the members giving notes, and the insurance is practiced almost entirely on the basis of premium receipts. The members pay full premium at rates fixed by the directors, and at the end of the year, when the losses and expenses have been deducted from the premium receipts, a dividend is declared and the members have returned to them the unused portion of their premiums.

RECIPROCAL UNDERWRITERS OR INTER-INSURERS

Reciprocal Underwriters or Inter-Insurers are groups of individuals who insure one another against losses by fire on a reciprocal or exchange basis. That is, each member of the group insures all the other members and in turn is insured by them, thus making each holder of a reciprocal insurance policy an *insurer* as well.

The plan is a development of the Mutual Insurance idea, in the sense that it is designed for the benefit of the members and each member helps to pay the losses of other members in return for similar assistance by them, but the two plans are distinctly different in two particulars—management and liability.

(1) The Mutual Company is managed by directors and officers who are members, while the Reciprocal Underwriters are managed by an individual or individuals who are not participating members, but are outsiders employed by the Reciprocal Underwriters and paid on a percentage basis.

(2) The liability of a member of a Mutual Company, as has been explained, is *pro-rata*, and is, therefore, variable and sliding, increasing and decreasing according as the insurances and losses of the company increase and decrease. Under the Reciprocal plan each member obligates himself for a certain amount of money and is not liable beyond this amount.

Reciprocal Underwriters are not incorporated; the members simply sign an agreement to perform certain acts. The persons or firm managing the association are active insurance men who are authorized by the articles of agreement to carry out the necessary insurance functions, this authorization taking the legal form of *power-of-attorney* and the manager of these associations having that title.

The articles of agreement of Reciprocal Underwriters provide for the organization and the conduct of the association and contain the following essential features:

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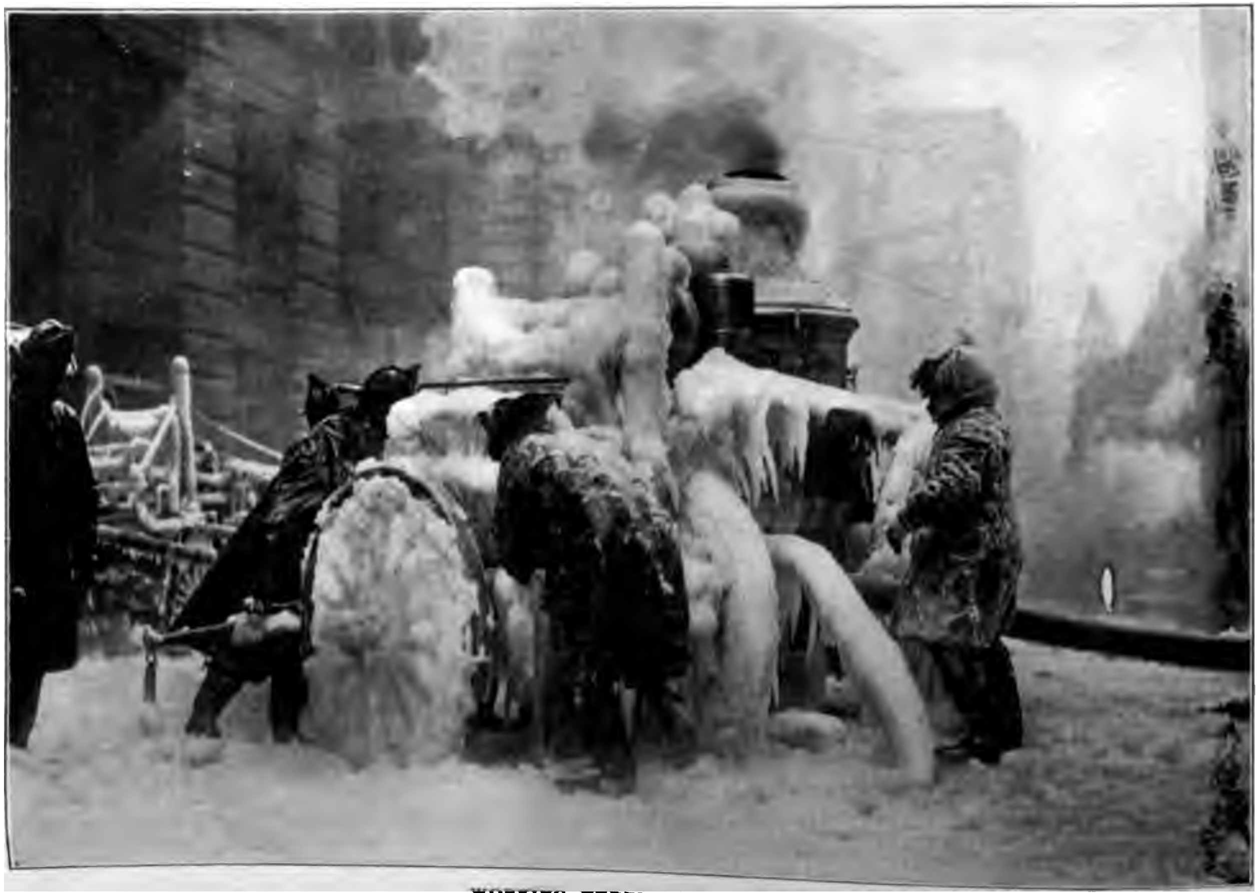


WORKING UNDER DIFFICULTIES

The Freezing of the Spray on Winter Days Makes the Position of the Firemen Very Difficult

1. The appointment of an attorney-in-fact with power to transact insurance in behalf of the signers of the agreement.

2. An Advisory Committee formed from the members to pass on the moral and financial responsibility of applicants, and to act as trustees of the subscribers' moneys and securities.

3. The establishment of an Emergency Fund, either by a deposit or by the accumulation of premiums, to which the subscribers add the amount of their subscription or underwriting agreement on any one risk.

4. The signing of an agreement by the members that they will insure other members for a specified amount. This fixes the maximum liability of one member to any other member.

5. Fixing and limiting the total liability of subscribers by the terms of the agreement.

6. The payment of interest on the money paid by the members into the Emergency Fund and the return to the members of the surplus money accumulated over and above the amount of the Emergency Fund.

7. The payment of premiums by members for insurance on their own property at current Joint-Stock Company rates.

8. The payment of the attorney on a percentage basis. In the practical working of the Reciprocal Underwriters organizations, the attorney is virtually a Fire Insurance Company in miniature. He collects the premiums, issues the policies, inspects the risks, pays the losses, distributes the interest and surplus, and carries out the entire transaction. As it is to his interest and advantage to maintain and develop the association, he also secures members and keeps the organization intact.

There are very few Reciprocal Underwriters' Organizations in operation, in fact, only three report to the New York Insurance Department, one of which is located in Chicago. As their operations, however, cover practically the entire country, a brief outline of their organization and methods is worth while.

Individual Underwriters

This organization was established in 1881 and has today nearly three-hundred subscribers or members. The amount of subscribers' deposits in 1909 amounted to $431,255.57, while the premium income for 1909 amounted to $412,407.88.

Each subscriber makes a cash deposit with the Advisory Committee equal to the maximum amount for which he is willing to insure any building or its contents belonging to the other subscribers. This amount may be $500, $1,000, $1,500, $2,000, as the subscriber elects. Interest at six per cent is paid on the Emergency Fund out of the premium income from members, and whatever surplus over that deposited in the Emergency Fund is also paid to members.

The attorney receives 15 per cent of the premiums for his services and all expenses.

Five subscribers, acting as an Advisory Committee, pass on applicants, act as trustees of the moneys and securities, and have the authority to retire a subscriber who becomes irresponsible.

The classes of risks insured are principally dry goods, hardware, boots and shoes, groceries, goods in storage warehouses, clothing, and factories with sprinkler equipments.

In case of an extensive fire involving a number of buildings, the policies provide that members shall be responsible for ten times the amount of their Emergency Fund Deposit and no more.

Reciprocal Underwriters

This organization was established in 1891 and has three hundred subscribers. The premium income for 1909 was $520,400.41. Subscribers are not required to make an initial deposit, but the premiums paid by them are held in trust by the Advisory Committee until they amount to $400,000, when this sum is used as an Emergency Fund. If, at the end of the year, there is a surplus over this $400,000, it is paid to the members. The conflagration liability is limited to $20,000. The Advisory Committee passes on applicants and the attorney-in-fact receives 15 per cent of the premiums for his services and expenses.

A special feature of this organization is that members who have buildings of large area can insure themselves separately and independently of the other members who have buildings of a different nature. This *large area segregation*, as it is called, amounts to a Reciprocal Insurance Organization. The amount of insurance is fixed at $5,000 on any one risk.

Indemnity Exchange

This organization was established in 1892 by members of the beef industry and has about three hundred members. The amount of initial deposits in 1909 was $59,896.11. The premiums for 1909 were $176,297.49, and the amount of insurance in force December 31, 1909, was $11,775,356.

The subscription by members is $100, where a single property is covered, and larger amounts, not to exceed $500, are permitted where the subscriber has several properties. The maximum insurance that could be written on any one risk would be the total amount of the member's subscriptions. The managers, however, have limited the maximum to $50,000 on any one property, and this maximum is written only on sprinkler-equipped risks.

Dividends to members are declared at the rate of 15 per cent, and are paid out of the premiums; in addition, members may withdraw, at the end of each year, all funds to their credit in excess of the amount of their subscription.

The management expenses are fixed by the agreement at 20 per cent of the premium. The funds paid in are under the control of trustees elected annually, who sit as an Advisory Committee. Bi-monthly bulletins are sent to the members and applicants may be elected when approved by all of the members.

In addition to these three Inter-Insurance companies, there are three other organizations, which, while practicing Inter-Insurance, do it under the form of Lloyds.

LLOYDS OR INDIVIDUAL INSURERS

When individuals on their own responsibility, instead of as companies or associations, furnish Fire Insurance they are called Individual Insurers or *Lloyds*, a term whose origin is an interesting insurance story.

Late in the 17th century, a group of persons made a practice of meeting in a coffee house kept by Thomas Lloyd, in Tower street, London, England; for in those times coffee houses, which correspond to the clubs of today, were the recognized and customary places for men to congregate.

These men were interested in ships and their cargoes, that is, marine business, and, as the many dangers of the sea made the insurance of ships and cargoes a very necessary thing as a protection to business ventures, it became the custom, therefore, for the owners to insure one another.

What they did was really Reciprocal Insurance, the insurance being made by owners for owners, and virtually on an exchange or reciprocity basis. Strictly speaking, the transaction was not insurance so much as it was investment, for various men took a part of the investment represented by the ship and its cargo, and agreed to share in the success or failure of the voyage. In other words, a man who wanted to protect himself against anticipated loss would give other men a part interest in the value of the project, and on the completion of the voyage, if it were successful, he would pay a portion of the proceeds as agreed, and if it were a failure, they, in turn, would pay him the portion that they had accepted as their venture.

In the course of events, this investment practice grew into a more strictly insurance transaction, and it also came about that the men participating in it changed from the men who owned ships or cargoes, to men who had no ownership or interest in them, but who furnished insurance on them for a certain price as a separate and distinct transaction. In other words, this meant the origin of Fire Insurance as a special business.

These men meeting at Lloyd's Coffee House became known as Insurers or Underwriters at Lloyds. As the business developed, the men participating in it felt the need of an organization, and they formed a society or association, more or less loosely bound together, which in time moved its headquarters from Lloyd's Coffee House to premises in the Royal Exchange, where the parent organization has its headquarters today. Following the Englishman's reverence for established customs, the original name of ***Lloyds*** was kept by the association, and is today the name by which the Individual Insurers are known the world over.

The making of Insurance at Lloyd's was done by each man signing his name on a sheet of paper opposite the amount for which he agreed to insure. This paper contained the terms or stipulations under which the signers bound themselves, and began with or contained the words "The Underwriters." This has resulted in the word *Underwriter* being used to designate a person who insures, and *Underwriting,* to designate the practice or business of insuring. If simplified language is ever introduced into the Insurance business, it will result in the use of Insurance in place of Underwriting, Insurer in place of Underwriter, and Individual Insurer in place of Lloyds.

This original group of Individual Insurers has developed into a famous institution of international importance. It is today known as Lloyds, London, and was incorporated by Parliament in 1871.

Lloyds, *as a group of insurers,* have always been principally identified with marine underwriting and, during one period, had a practical monopoly in this form of risk. It is today the greatest marine insurance organization the world has ever known. Some of its members practice Fire Insurance as well as insurance against any event or contingency for which insurance is desired.

Lloyds, *as a corporation,* does no insurance. It is governed by a committee and simply provides facilities for its members to do business, such facilities being principally a headquarters or exchange and the collection of special information concerning vessels. It is really a great market for insurance, and so long as the members conform to the rules of the society or corporation, they are allowed to follow their own views in the matter of doing business. Applicants for membership at Lloyds must have satisfactory financial standing and, in addition, each must deposit with the committee a sum of not less than $25,000, which is in the nature of a guarantee that he will fulfill his business contracts.

In the practical working of Fire Insurance at Lloyds, London, each underwriter or Individual Insurer signs a policy for the amount that he insures. Groups or syndicates composed of a limited number of individuals will furnish insurance by designating one active Underwriter as their agent. The liability of the insurers, however, is individual and not joint, so that any suit or action to recover must be laid against each Individual Underwriter.

Lloyds, London, and Lloyds in the United States should be clearly differentiated, for in the United States, the word has been used as the trading name of an association or partnership, whose history and practices have been such as to discredit the name and give this type of insurance the reputation of being unreliable.

The first Lloyds, having its home office in New York, was organized in 1866. It had one hundred Underwriters and each Underwriter deposited $1,000 with an Advisory Committee, thus making a total Initial Deposit or Safety Fund of $100,000. From 1866 to 1892, stimulated by the success of the early companies and by the fact that they were not subject to the provisions of the laws applicable to Stock Fire Insurance Companies, a considerable number of Lloyds associations started business. Some of these had a very limited financial responsibility and few adopted the safeguards which are characteristic of Lloyds, London. Since 1892, however, the insurance laws of New York State have been revised and a systematic effort made by the authorities to prevent irresponsible Lloyds from doing business. The laws at present give the State Superintendent of Insurance supervision over such associations. This has not only resulted in keeping check on the operation of the irresponsible Lloyds, but has tended to protect the Lloyds that are being honestly and properly conducted from the evil reputation which has been given to this class of Insurers.

The Lloyds that are operating in New York State have the following general features of organization: an attorney-in-fact; a number of Underwriters who assume a stated liability; a deposit fund; a yearly declaration of profits; an Advisory Committee; articles of association filed with the State Superintendent of Insurance; and an annual financial statement filed with the State Superintendent of Insurance.

In addition to the Lloyds associations, which transact Fire Insurance on the basis of profit, there are three associations which are operated under the form of organization of Lloyds, but are in reality Inter-Insurers because their transactions are confined entirely to their own members. One of these organizations is composed of the owners of confectionery stores in New York City, while the other two are composed of owners of large dry goods and mercantile establishments.

METHODS AND ORGANIZATION OF COMPANIES

STOCK FIRE INSURANCE COMPANY

In the conduct of a Stock Fire Insurance Company, as already stated, it is usual for the directors to concern themselves chiefly with the financial or banking department of the company's business, leaving technical matters connected with the insuring of property to the officers of the company and their assistants.

The president and other officers exercise a general control over all the departments of the company, decide upon the general policy, the methods to be used, and the amount for which liability may be assumed on different kinds of risks. They also lay out the plan of campaign which is to be executed by the department managers through their special and local agents. In the case of those companies which do not make use of separate departments or general agencies located in different parts of the country, it is customary to provide a larger staff than usual at the head office, the junior officers performing the duties usually devolving upon the department managers.

Departments. It is the usual practice to divide the country into districts or departments, with one or more officers at the head of each division, although these departments are in some cases under the immediate supervision of the chief executive and directed from the head office of the company. The majority of companies establish a department in each of several large cities and include in that district the States naturally tributary to the city which has been selected. These departments, are as a rule, called *general agencies*, and the officer in charge the *General Agent.* Cities usually selected for the departments are New York, Chicago, San Francisco, and to a smaller extent, Boston, Philadelphia, Atlanta, New Orleans, and one or two others.

Local Agents. These general agencies are intended to thoroughly work the territory under their jurisdiction according to the general scheme of operations adopted by the company, securing business by means of agents residing in the various towns and villages where the company wishes to operate. These men—called *local agents*—are the means by which the company comes into direct contact with the insuring public, and from whom the business on which it feeds is secured.

The departments or general agencies keep in touch with the local agents by means of *special agents,* who travel constantly over the field to which they are assigned, locating agencies at all available points and carefully inspecting and securing accurate information concerning all the risks which the company insures. As the local agents are a factor of supreme importance to the business, it is the endeavor of the companies to maintain cordial and friendly relations with them, the special agents having not only the duty of properly supervising the business of the local agents, but also of making the company popular with them. They establish new agencies, discontinue unsatisfactory ones, collect overdue payments, arrange with claimants for settlement and payment of losses and, in general, do everything to further the interests of the company in every legitimate way.

Each local agent is equipped by the company with the various books of record, blank unsigned policies, and other supplies necessary for the transaction of the business. When he secures a contract from a property owner, he fills out, executes, and delivers the policy and as soon as possible thereafter makes an abstract of the contract. This abstract contains a full description of the property and all the details of the contract and is made out on a special blank provided for the purpose called a *daily report.* This report is at once mailed to the department or general office which has jurisdiction over the territory in which the agent is working, and, at the end of each month, an account or statement of all the contracts made during the month is sent by the agent to the same department office, accompanied or followed by a remittance for the premiums collected.

The local agent is compensated in cash—usually 15 per cent of the amount of premiums secured or renewed by him. He is expected and required to protect the interests of the company he represents by carefully selecting desirable business and by obeying their instructions in all matters. The business secured by the local agents—that is, the risks insured and the policies written—is under strict supervision of the department or general office.

Examiners. The daily reports from agents are carefully inspected and reviewed by *examiners.* The duties of the examiner are extremely important; he must have a clear head, cool perceptions, careful judgment, and a very considerable knowledge acquired by experience. He must have an intimate acquaintance with the hazards usually incident to various kinds of property, as well as a familiarity with the conditions of a district or town where the risks are located.

In judging a risk, the examiner considers the character of the ownership, the nature of the inherent and adjacent or exposing hazards due to the various occupants in the vicinity, the amount and quality of the protection against fire, the record of the locality as to fires, the rate, and numerous other factors affecting the desirability of the risk. The policies issued by the local agents are carefully examined and reviewed and if the wording of the contract—that is, the "form"—is found to be faulty, if the rate is too low, or any other error exists, the examiners are expected to discover it and notify the local agent to make the necessary changes; or, if the property insured is considered undesirable, the local agent is notified to cancel or terminate the insurance.

To facilitate the work of the examiners, they are supplied by the department or general agency with *maps* showing the construction of every building in the business districts of all towns of importance. They have also *personal reports* indicating the financial standing and the business records of all merchants and manufacturers; inspection reports of important risks made by special agents and inspectors; and various tables, books of reference, and rules as an aid in passing judgment upon the daily reports which are sent in by the local agents.

Reports. The monthly accounts or statements made by local agents are carefully gone over by auditors or bookkeepers, and when the work of examining or auditing is finished, the daily reports and accounts pass into the hands of a large force of clerks, who make up from them the elaborate records and statistics which the insurance companies are required to keep, partly for their own use or guidance and partly to comply with the laws of the different States.

At the end of the year the transactions of the different department offices are forwarded to the head office of the company, where all the figures are combined with a detailed list of the assets and liabilities of the company and with other particulars affecting its business and financial conditions to form the *annual statement.*

The annual statement also shows two general items of income and two of outgo. The income arises from the *premiums* and the *interest on investments.* The outgo arises from the *losses* and the *expenses.*

The *loss ratio* is the percentage of the annual premiums which is required to pay losses. In well-managed companies this percentage ranges from 45 per cent to 65 per cent according to the losses for the year. It almost never falls below 45 per cent—a figure which indicates an abnormal profit—and it frequently reaches 65 per cent or even higher; the latter figure is close to the danger line and when reached usually means a net loss on the year's business.

The *Expense ratio* may be divided roughly as follows:

Commissions to agents	20 per cent
Salaries and expenses of special agents, adjusters, and inspectors	4½ per cent
Taxes	2½ per cent
Maintenance of departments and head offices, including salaries and other expenses	13 per cent

MUTUAL FIRE INSURANCE COMPANIES

Mutual Fire Insurance Companies may be divided into three classes according to their size and operations: (1) local, county, or town mutuals; (2) state or general mutuals; and (3) manufucturers' or factory mutuals.

Local or County Mutuals. The local or county Mutual Fire Insurance Companies are by far the most numerous of any class of companies in the United States, their number being approximately 1,500, of which 125 are in New York State alone. Usually their operations are limited to a non-hazardous class, such as farm property, dwellings, churches, and stores in a given and limited district like a town or county, although in New York State a local Mutual Company may operate throughout five counties.

In order to start such a company, applications—*i. e.*, promises for a stated amount of insurance, usually somewhere between $50,000 and $200,000—must be already on file and a portion of the premiums therefor—generally 25 per cent—paid in advance in cash.

When the necessary applications are secured, the men who are organizing the company obtain from the State authorities the proper papers of incorporation, and then hold a meeting of the applicants or members and elect officers.

Business is then begun by issuing policies of the company to the original applicants and any of their friends who may be induced to join them, for it is an important point to have a considerable number of policy-holders among whom the losses may be divided. The applications for insurance are usually passed upon in respect to valuations, desirability, etc., by an executive committee or Board of Directors, and if they are approved, policies are issued by the Secretary and papers are signed by one or two members of the committee.

Policies are issued on the payment of a small sum in cash equal to about one-fourth the price commonly charged by Joint-Stock Fire Insurance Companies, and, in addition, a note is given by the member for an amount equal to three or four times the cash payment. These notes are subject to call, if the needs of the company so require. The policies are usually issued for a term of five years.

Each policy-holder is liable for the losses of the company according to the articles of agreement or incorporation, or according to the by-laws of the particular company in which he is insured, the limit of liability usually being stated in the policy. Sometimes the policy-holder is liable for his fractional share of any or all liabilities which may come to the company, but this liability is more often limited to a stated percentage of the amount of insurance the individual carries, or the same multiple of the amount for which he has given premium notes.

In most cases all the work of the company is done by the secretary, who is very likely the village postmaster, storekeeper, or bank cashier, and who receives either a fee for each policy issued, or a regular salary. As the Executive Committee and all the applicants and members are neighbors or acquaintances, the personal and financial qualifications of every applicant as well as the value and condition of his property are well-known, a fact which reduces the danger from dishonest losses or over-valuation to a minimum. No man with a poor reputation can secure insurance in one of these institutions if it is properly conducted; and moreover, every policyholder is constantly under the eye of his neighbors, many of whom are members of the same company, so that the opportunities for a successful commission of fraud are not many.

These companies, even when wisely and honestly managed, succeed or fail according to the burning-record of the district in which they operate. A few heavy losses in the early years of their existence usually end them, as farmers and villagers quickly tire of assessments. On the other hand, in districts which have favorable fire records, these little companies live and prosper for years. Often they accumulate assets of considerable value and in such cases furnish indemnity to their members at a very low cost. They can be very economically operated, because they have no expenses of any kind save the payment of the secretary and the cost of their supplies; they are also free from the burden of taxation which rests on Joint-Stock Fire Insurance Companies. Their strength and their weakness alike are largely due to the fact that they transact business in a very limited field, where every risk is known and watched, but where comparatively few losses make insurance very costly, owing to the limited number of those among whom the losses are distributed.

State Mutuals. The State Mutual Fire Insurance Companies are distinguished from the Local Mutuals in that they do a general business throughout one or more States. In organizing these companies, the various State laws require applications for a very large amount, Wisconsin, for instance, setting the figure at $750,000. In some States the classes of business which these State Mutuals may write are limited by law; in others, the maximum liability which may be assumed in any one risk is also fixed. The Wisconsin Fire Insurance Law is remarkable in that it provides specifically for five kinds of Mutual Companies, which may transact business over an extended territory. Among them are companies formed by retail lumber dealers, hardware dealers, church societies, and the treasurers of county insane asylums and poorhouses.

These general or State Mutuals have on the whole not been successful, for ordinarily they do not have sufficiently strong assets and they cannot secure business in districts remote from their place of organization, except by giving dangerously low rates. They are also compelled to delegate to agents or others the power of selecting risks and do not always get the best service; furthermore, those who operate the company are without the incentive of profit, which is a most important factor.

Such companies commonly do not possess and cannot acquire the competent staff, the complete organization, and the concentrative authority necessary for the successful prosecution of a general business under competitive conditions throughout a wide territory. When such powers are given to an official of a Mutual company, the trust is too often abused. So long as the business grows rapidly, the heavy assessments are avoided—the loss ratios on a rapidly growing business are naturally small—the members are not likely to interest themselves in the methods pursued, and by the time the assessments become heavy, it is usually too late to apply a remedy.

Manufacturers' Mutual Companies. These companies are by far the most important of the Mutual companies. They have a great influence on Fire Insurance companies in general, because of their methods of dealing with the fire loss. They were, in fact, primarily devised for the prevention of loss by fire, with the payment of indemnity for losses sustained as a secondary matter. They owe their existence to the fact that cotton and woolen manufacturers sought to improve their property, so as to reduce the number and the amount of losses, and, therefore, to reduce the cost of insurance.

The first of these companies was organized in 1835 by Zachariah Allen in Providence, Rhode Island, and was called the Providence Manufacturers' Mutual Company. In 1850 there were three of these companies and in 1860 the number had increased to seven. There are now eighteen such companies in active operation in Rhode Island and Massachusetts, and several more in Pennsylvania and other parts of the country. These companies are carrying insurance amounting to over $1,000,000,000 on factory property.

From the outset, these companies have endeavored, first, to ascertain and eliminate the causes of fire, and second, to provide such ample protection that any fire which might occur would be extinguished with but slight loss. Their success has been ascribed to the following principle: *The only persons who can prevent loss by fire are the owners or occupants of the insured premises. Upon them rests the responsibility for heavy loss, if any occurs, in nearly every fire. All that the insurance company can do is to pay indemnity for loss which, if large, in nine cases out of ten, is due to the lack of apparatus for preventing loss or to the lack of care and order in the conduct of the work.*

In their efforts to ascertain and to eliminate the causes of fire, these companies have investigated and endeavored to safeguard all processes used in manufacture; they have investigated methods of illuminating, heating, and lubricating; they have devised elaborate plans for the safe construction and arrangement of factories; and finally, they have tested and applied the most modern and approved apparatus for extinguishing fires.

Moreover, when a factory comes into the membership of a Manufacturers' Mutual company, that company not only sees to it that in all respects the factory conditions are brought up to the proper requirements, but, by frequent inspection, secures the constant maintenance of such conditions. Such companies are, indeed, hardly to be called insurance companies at all, but rather *fire prevention companies*—associations of manufacturers with experienced inspectors and engineers whose work it is to eliminate the possibility of loss or serious damage by fire. The insurance feature only comes into play when, despite their precautions, a damage is incurred. It will be realized that, though the number of fires and the loss resulting therefrom have been very greatly reduced by these methods, a large expenditure is necessary to construct, arrange, and equip a factory in such a way as to bring it up to the standard of their requirements.

Their insurance method is to charge a cash premium, based upon the class of work done, the construction of the building in question, and the extent and efficiency of the apparatus for extinguishing fires. No factory can secure the protection of this system, unless in respect to all these matters, it comes up to a prescribed standard of excellence. In addition to this cash payment, a liability for assessments equal to five times the cash premiums is assumed by the policyholder. As a matter of fact, however, since 1850 no assessment has been found necessary by any of the New England companies. On the other hand, the cash premiums have not only paid the losses and expenses, but have enabled a division of profits to be made at the close of each year. In this way the actual cost of indemnity is reduced to a small amount.

FIRE INSURANCE ASSOCIATIONS

Fire Insurance is a transaction so complex and far-reaching that in its development there have been produced a number of organizations with quite different purposes and activities. The experience of the various individual companies has resulted in certain combinations, particularly for the support and maintenance of organizations whose duty it is to perform specific functions that are necessary for the business, but which could not be economically performed by the several companies themselves. These organizations may be classed as follows: Underwriting; Inspection; Rating; Engineering; and Salvage.

Underwriting. The underwriting organizations are formed for the discussion of underwriting ethics; the maintenance of statistical data; the dissemination of information; the promotion of uniform rules of practice; the passage of proper laws; the prevention of incendiarism; and in general, the improvement of Fire Insurance as a business, as well as the making of *underwriting* intelligent, scientific, and reliable.

Inspection. The inspection organizations are formed for purposes of economy and efficiency. The inspection of a risk by a board or bureau, operating in behalf of a number of companies, gives to all its members, the results of its investigations, so that they in many cases can dispense with an inspection made by their own employes. In addition to this, the concentration of the work of the inspectors in their particular field develops better experts and, therefore, gives the companies more efficient service than they individually might be able to secure.

Rating. The rating organizations are formed for the purpose of making a single or uniform rate, which may be used by a number of the companies. Such an organization makes for economy, because a rate can be made for a number of companies at about the same cost as for each individual company. It also provides uniform rates, thus doing away with unwholesome competition among the companies that would put the price of insurance below its proper cost, and would thereby reduce the income of the companies below the standard necessary to maintain them in a sound financial condition.

Engineering. The engineering organizations have been created because it has been found, as a matter of experience, that with only ordinary precautions the number and extent of fires result in financial losses beyond the ability of Fire Insurance to replace. It is their purpose to reduce the fire loss by the application of preventive measures and by the more active use of protective or extinguishing measures.

Salvage. The salvage organizations are maintained in the large cities by insurance companies for the purpose of reducing damage at fires. They consist of bodies of uniformed men called the *salvage corps* or *fire patrol,* who supplement the work of the Fire Department by assisting in extinguishing fires whenever possible, but whose principal duties are to prevent water damage by spreading water-proof covers over property which is in danger of being wet, and to watch the property affected by the fire until the loss has been adjusted.

NATIONAL BOARD OF FIRE UNDERWRITERS

The National Board of Fire Underwriters is the largest organization of companies known to the insurance world. Its headquarters are in New York City, but its membership comprises practically all the companies doing a general Fire Insurance business throughout the United States, its membership on May 1st, 1910, being one hundred and seventeen companies.

Committees. The function of the Board is advisory but through its committees, a few of which are mentioned below, it does a number of important things.

Laws. The committee on laws works to secure laws and regulations which will give the proper stability and solidity to Fire Insurance capital, and to protect the institution against oppressive legislation. It acts only where a principle of wide application is involved or where practically the entire membership of the board is concerned.

Incendiarism and Arson. The committee on incendiarism and arson offers rewards for the arrest and punishment of criminals guilty of these crimes. Since 1873, 5,975 rewards have been offered aggregating $1,982,225, which have resulted in 392 convictions and the payment of 277 rewards amounting to $83,719.

Statistics and Origin of Fires. The committee on statistics and origin of fires prepares a number of tables showing the extent and character of the Fire Insurance business. Tables of risks written, premiums, and losses, give for the period from 1860 to 1909:

Amount of risks carried by Fire Insurance companies.	$589,300,134,475.00
Premiums received.	4,839,973,433.00
Losses paid.	2,832,997,641.00

These figures establish the following ratios:

Ratio of losses to $100.00 of premiums. .	58.53
Ratio of losses to $100.00 of insurance. .	.4807
Amount of insurance on risks to $1.00 of loss.	208.01

Tables of risks written and premiums charged show that from 1871 to 1909 inclusive:

Insurance written amounted to.	$552,976,666.390 00
Premiums charged amounted to	5,875,656,037.00
Rate of premiums charged on each $100.00 of insurance was.	1.0626

Table of expenses shows that from 1860 to 1909:

Premiums written were.	$5,079,317,309.00
Expenses were.	1,832,097,248.00
Giving a ratio of.	36.07

Table of commissions shows that from 1860 to 1909:

Commissions amounted to.	$955,107,769.00
With a ratio to $100.00 of premium receipts of.	18.80

The table of annual fire losses gives figures for the thirty-four years from 1875 to 1909, and other tables show the taxation of Fire Insurance companies, the average rate of premium and loss by States, the business by terms, and the amounts of outstanding risks at the end of each year.

Fire Prevention. The committee on fire prevention maintains a corps of inspectors and engineers, who visit the various cities and towns of the country and make the reports covering the fire conditions of the localities. These reports cover the city or locality as a general Fire Insurance proposition and take up in detail the efficiency of the water supply, the fire department, the fire department auxiliaries, the fire-alarm system, the building department, explosives and inflammables, electricity and conflagration hazards. Specific recommendations for the improvement of these departments are made to the municipal authorities and co-operation is sought from business organizations to have them carried into effect.

Heating, Lighting, and Patents. The committee on heating, lighting, and patents, have duties in conjunction with committees and associations hereafter mentioned.

Consulting Engineers. The committee of consulting engineers considers processes relating to heating hazards, other than electricity, and has drafted rules covering the more important hazards made by gas and gasoline lighting systems.

National Fire Protection Association. The National Fire Protection Association was organized in 1896, its object being to bring together various associations and bureaus interested in and encouraging better building construction and the best and most approved fire-fighting apparatus, particular attention being given to automatic sprinklers, a form of protection which, for all practical purposes, was at that time almost unknown to stock underwriters.

Its present membership consists practically of all rating organizations, associations, and bureaus, located in the United States and the Dominion of Canada, interested in the introduction and encouragement of conditions affecting and materially reducing the destruction of property by fire.

The Association has a large list of associate members, who are located in nearly every part of the civilized world and who contribute to its support and receive its publications. The Secretary of the Association also publishes a quarterly bulletin of Fire Hazards.

The National Fire Protection Association has prepared rules, requirements, and specifications on the following subjects which are distributed in pamphlet form as part of the work of this committee:

LIST OF RULES, REQUIREMENTS, AND SPECIFICATIONS

Acetylene gas machines and storage of calcium carbide
Coal-gas-producers
Fire Department—private—suggestions and organizing
Fire doors and shutters
Fire extinguishers, chemical, for other than fire department use
Fuel oil, storage and use
Gas and gasoline engines, construction and installation of
Gasoline vapor gas-lighting machines, lamps, and systems
Gasoline stoves for cooking and heating
Grain driers, construction and installation of
Hose couplings and hydrant fittings for public fire service, with details and dimensions of the National Standard
Hose, private department, for mill yard use
Hose, public fire department use
Hose houses for mill yards, construction and equipment of
Hose, unlined linen, manufacture of
Hydrants for mill yard use, construction of
Incubators and brooders, construction and installation of
Kerosene oil pressure systems, construction and installation of, for lighting and industrial uses
Lightning, protection against
Pumps, centrifugal fire
Pumps, electric fire
Pumps, rotary fire
Pumps, steam fire
Pumps, governors and auxiliary pumps (steam)
Railway car storage and operating houses (standard), construction and protection of
Signaling systems used for the transmission of signals affecting the fire hazard
Skylights, construction and installation of
Sprinkler equipments, automatic and open systems, installation of
Storage systems for 250 gallons or less of fluids which at ordinary temperature give off inflammable vapors
Uniform requirements relating to slow burning construction, inferior construction, general hazards, oil rooms, general protection, stair and elevator enclosures, watchmen, thermometers, etc.
Waste and safety cans, fire pails, etc.
Wired glass and construction of frames for wired and prism glass used as a fire retardment, manufacture, construction, and installation of

LIST OF APPROVED DEVICES

Acetylene gas machines
Doors, corridor, or partition
Dry pipe valves for use in connection with automatic sprinkler equipments
Fire doors and shutters, standard tin clad
Fire doors, hardware for

Fire extinguishers, carbonic acid gas, hand, for other than fire department use
Fire hose, 2½-inch cotton, rubber lined, for mill yard use
Gasoline engines, stationary
Gasoline vapor gas-lighting machines, systems, and lamps
Gasoline stoves for cooking and heating
Gas-producers, suction
Kerosene oil pressure systems
Linen fire hose, unlined, for use inside buildings
Sprinklers, automatic
Storage and supply systems and receptacles for 250 gallons or less of hazard fluids
Watchmen's time recording apparatus
Window frames for wired glass

Underwriters' Laboratories. As an outgrowth of the National Fire Protection Association, the Underwriters' Laboratories have been established in Chicago as part of the work of this committee, $18,000 having been appropriated for its maintenance. The laboratory conducts tests and experiments on fire appliances and systems, and maintains a system of inspection at factories where fire appliances are made, with a system of labels designed to distinguish appliances made under this inspection system. During the year 1909 a total of 16,815,920 labels were used.

The Underwriters' National Electric Association has drafted a *National Electrical Code,* which contains the standard specifications for all electrical machinery and installations. It is quite generally used by municipal inspecting departments, electrical manufacturers, and contractors.

Electrical Department. The electrical department of the National Board of Fire Underwriters operates for the suburban territory of New York City, and maintains a staff of inspectors who inspect the electrical features of risks in that territory.

Construction of Buildings. The Committee on Construction of Buildings has prepared a National Board Building Code intended to secure the adoption of a uniform building code throughout the country.

DEPARTMENTS AND BRANCHES OF FIRE INSURANCE

Specialization is a natural result in the development of as complicated a transaction as Fire Insurance and this has taken place to so great an extent that there are a number of departments or branches which have come to be considered as distinctly separate in their work. A man working in one branch is practically compelled to devote himself entirely to that line of work. Fire Insurance has its commercial as well as its technical or strictly insurance aspects; it is a business conducted for the purpose of making money, and, therefore, is naturally managed like any other business enterprise. This, of course, does not apply to the Mutual Companies and the Inter-Insurers, which have been established not to make money but to give service to their members; in the case of the Joint-Stock Companies and the Lloyds or Individual Insurers, insurance is a business proposition.

GENERAL BUSINESS MANAGEMENT

Among its general commercial aspects, *i. e.*, what might be called the *business management*, there is the important question of financing, or investing the moneys and funds in possession of the company. A Fire Insurance Company naturally maintains a large account in the shape of capital, surplus, and unearned premiums, which cannot be permitted to remain idle, but must be used to produce as large an income as possible; in fact, the income derived from investments is a large factor in the success of the company. The financiering is usually in the hands of some one officer or director of the company.

The *office management* of a company differs only in details from the office management of any other business enterprise, and is merely a question of keeping proper accounts and records, and the employment of an adequate number of cashiers, bookkeepers, and clerks.

The *soliciting* or *business-getting* department of a Fire Insurance Company is similar to the sales department of any business enterprise. Its duty is to see that the company secures sufficient desirable business to justify the use of the capital and the maintenance of the business organization. While the soliciting of Fire Insurance may be considered only a matter of ordinary business salesmanship, it is usually performed by agents or brokers, who, in addition to being business-getters, are also expected to be insurance men and, therefore, to be sufficiently versed in the technical features of Fire Insurance. The *technical branches* of Fire Insurance are *inspection, rating, underwriting, adjusting,* and *brokerage.*

SPECIAL BUSINESS MANAGEMENT

Technical Insurance Functions. *Inspection.* The inspection department or branch of Fire Insurance has to do with what is called the field work, because it is done away from the office and is concerned with buildings, their location and other features. The work of a Fire Insurance inspector consists in making observations and describing or reporting the conditions of risks or buildings, which affect the question of insurance. The *inspector* is a combination of reporter and detective; he must be a good searcher or investigator, able to see things, not only as they appear on the surface but as they are underneath, and in their true condition. He must be wide awake; he must keep informed and up-to-date concerning new processes or methods. He must be able to match his wits and skill against the wits and skill of the property owners, and their employes or agents, who are frequently not averse to taking advantage of the Fire Insurance company by misleading the inspector or simply letting him trust to his own devices and ability to get the information that is needed by his company.

From this suggestive outline of inspection work, many students will be able to judge whether the work would attract them and whether they could hope to be successful in it. Inspection work is very much desired by many men in the insurance business because of its freedom from office routine—the work being done outdoors to a great extent—and because of the constant competition which the inspector faces, with the risk itself as a passive opponent and the occupants of the risk as active opponents.

Rating. The rating department or branch of Fire Insurance has to do with measuring the fire and insurance cost of risks as a whole, and as to their separate features—*i. e.*, the price-making part of the Fire Insurance Machine. Rating, being mathematical in its scope, offers a fascinating field to those who understand and appreciate the possibilities of figures, but in the very nature of things it demands rather close confinement to desk or office and attention to routine work. It, however, is one of the most important features of Fire Insurance, and is bound to become still more so, because of the general agitation over Fire Insurance rates.

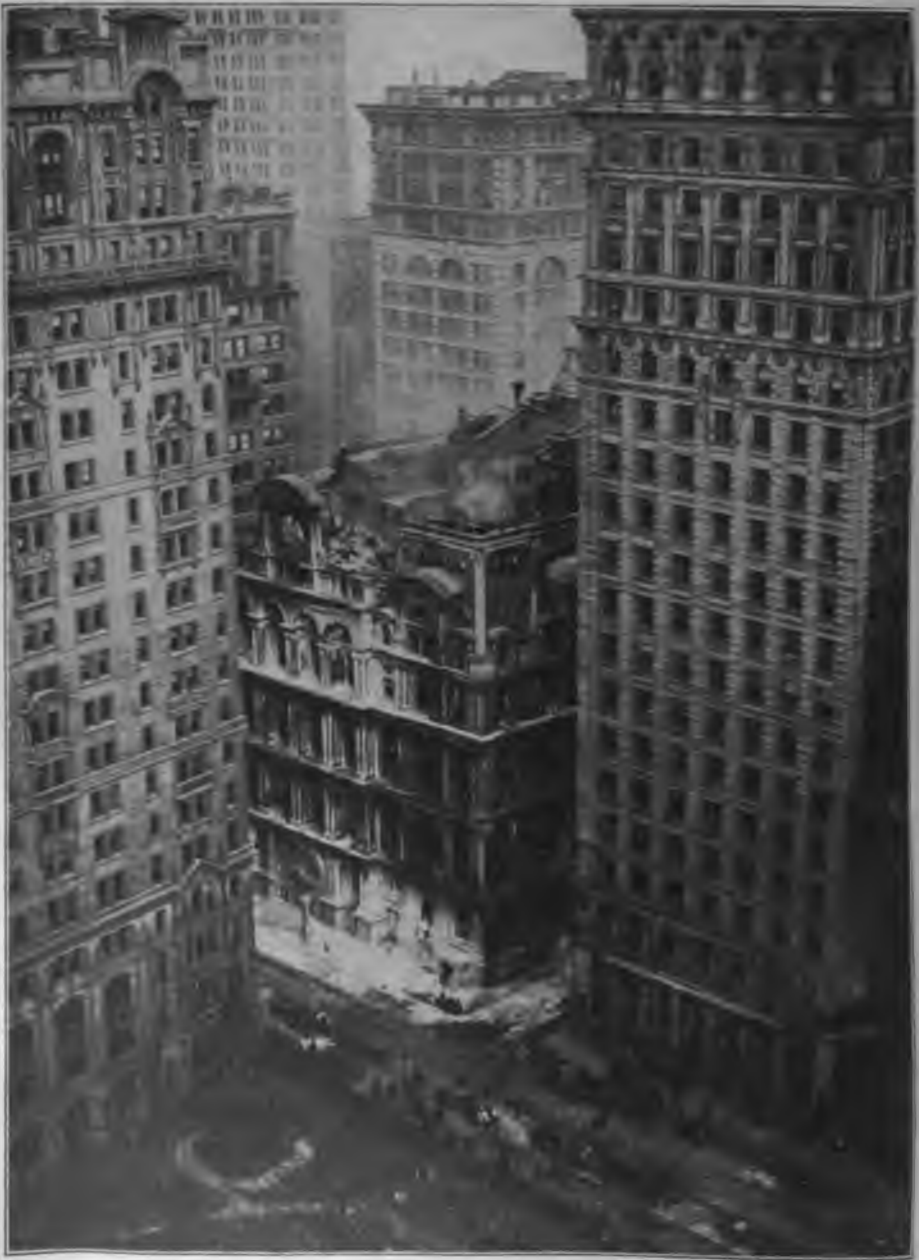
Adjusting. The adjustment of losses and the settlement of claims demand a knowledge and experience along varied lines of work. An *adjuster* must be something of a lawyer, because of the legal questions which arise regarding the policy and its application; he must be a good business man because a settlement of claims frequently resolves itself into a competitive proposition; he must be a walking encyclopedia of prices and values of all kinds of articles, because the claims of the property owners or insured must be checked or verified in order that the company may pay only the real loss or damage; and, finally, he must be a fair detective, in order to protect his company against incendiary fires and fraudulent claims. Since adjusting means the saving or the losing by the company of definite and large amounts of money, it need hardly be said that competent adjusters are in demand.

Underwriting. The underwriting department or branch of Fire Insurance offers the highest possible position in Fire Insurance, for the selection of the risks which shall be insured is the foundation stone of the entire Insurance transaction. The *underwriter* is a judge, a selector, or discriminator; he is called upon to use knowledge, facts, experience, and records; he must follow his instinct, or judgment; he must be a guesser or a prophet; and he must have foresight rather than hindsight. When all of these qualifications are considered, it still leaves underwriting and the underwriter considerably short of a full explanation. It is said that underwriters are born, not made; certain it is that they usually achieve their positions by a process of gravitation or natural selection—that is to say, they are drawn into the place by some magnetic attraction. It seems useless to suggest that a man should start out with the intention of being an underwriter, for if he has the qualities to fill such a delicate and responsible position, he will land there just as quickly as his company finds out his value in that department.

Agency. The agency department or branch of Fire Insurance is a combination of business and insurance. In fact the *agent* is almost a Fire Insurance company himself, for he must be successful as a business man and as a business-getter, in order to hold his agency, while at the same time he must be a competent and a practical Fire Insurance man in order to give his company the proper support and to give his customers and clients the technical assistance they require.

The position of agent is generally considered a very desirable one; in fact, one prominent underwriter called the local agent the most independent man on earth. He has the advantages of conducting his own business, and also developing a valuable line of customers and, if successful, he is in a position to make advantageous arrangements with the companies. A successful agent, like a successful underwriter, must apparently be produced by passing through the insurance mill, and must be thoroughly familiar—even though not an expert—with inspection, rating, adjusting, and underwriting, because, otherwise, it does not seem reasonable that he can properly perform his duties.

Brokerage. The brokerage department or branch of Fire Insurance is similar, in many respects, to the agency branch. The *broker* is primarily a business-getter, and in order to get business he must obtain the good will of insuring property owners, who will place their insurance in his hands with the implied understanding that the broker will look after their interests. This puts upon the broker a great responsibility, for he virtually becomes the agent of the property owner and must protect his client's interests against those of the insurance company if necessary. The broker's principal technical functions are concerned with rating and adjusting. He must first be a practical expert on rates, for he will be expected to purchase insurance for his clients at the lowest possible cost; but still more important is his assistance in case of a loss, for it will be his duty to have his client's property so protected, that no question or dispute can arise in case it is necessary for a client to make a claim upon the company. In the actual settlement of claims, the broker is also expected to act as his client's adjuster, although this activity is now performed in some localities by specialists who are known as *public adjusters.*



THE OLD EQUITABLE BUILDING AFTER THE FIRE
This Building was Completely Surrounded by Modern Fireproof Office Buildings

FIRE INSURANCE RATING

PART I

DEVELOPMENT OF INSURANCE RATES

EARLY METHODS

Definitions. The *rate of insurance* is the amount charged for each one hundred dollars of insurance. Rates are today commonly divided into two classes, *minimum* and *specific.*

The *minimum rate* usually applies to large classes or groups of risks representing no high degree of hazard but fair uniformity in the hazard represented, such as dwelling houses, and may be (1) the lowest rate that may be charged for a given class; (2) a rate distinguished from a specific rate in that it applies to a large group of risks. A *specific rate* is one that applies to a specific business or property at a specific location. Specific rate applies where the hazard rises above the ordinary, or where, owing to the area, size, height, or kind of construction, as fireproof, the problem can only be handled by a specific, or as it might better be termed, an individual rate.

A risk will usually have at least two rates, one for the building and one for the contents. The simplest example would be a dwelling house where the building, if brick, will take a lower rate than the contents, which are the household furniture. Again, a risk may have several different rates, owing to the nature of the business; thus a jeweler would have a rate for the building, a general rate for his contents, and then other rates for the contents of the fireproof safes or vaults, these rates themselves varying for different articles.

An *average rate* is frequently made where property is specifically rated and may arise in one of two ways:

(1) If the property is in two or more buildings, the rates being different, the value of the property in each building will be submitted and an average rate based on these values will be promul-

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TABLE I

Rates Based on Rental Value

Pound Rent	Insured for 7 years			Insured for 11 years			Insured for 21 years			Insured for 31 years			Houses Burnt Money Paid		
£	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1	0	2	6	0	3	6	0	5	0	0	5	6	10	0	0
2	0	5	0	0	7	0	0	10	0	0	11	0	20	0	0
3	0	7	6	0	10	6	0	15	0	0	16	6	30	0	0
4	0	10	0	0	14	0	1	0	0	1	2	0	40	0	0
5	0	12	6	0	17	6	1	5	0	1	7	6	50	0	0
6	0	15	0	1	1	0	1	10	0	1	13	0	60	0	0
7	0	17	6	1	4	6	1	15	0	1	18	6	70	0	0
8	1	0	0	1	8	0	2	0	0	2	4	0	80	0	0
9	1	2	6	1	11	6	2	5	0	2	9	6	90	0	0
10	1	5	0	1	15	0	2	10	0	2	15	0	100	0	0
20	2	10	0	3	10	0	5	0	0	5	10	0	200	0	0
30	3	15	0	5	5	0	7	10	0	8	5	0	300	0	0
40	5	0	0	7	0	0	10	0	0	11	0	0	400	0	0
50	6	5	0	8	15	0	12	10	0	13	15	0	500	0	0
60	7	10	0	10	10	0	15	0	0	16	10	0	600	0	0
70	8	15	0	12	5	0	17	10	0	19	5	0	700	0	0
80	10	0	0	14	0	0	20	0	0	22	0	0	800	0	0
90	11	5	0	15	15	0	22	10	0	24	15	0	900	0	0
100	12	10	0	17	10	0	25	0	0	27	10	0	1000	0	0

gated. The advantage of this is that it enables the insured to have one policy covering his property in all the locations without paying the highest rate. Hence if the stock shifts from one building to another daily or hourly it does not require such a close accounting to follow the values in each building.

(2) In a fireproof building where the values vary on different floors and the rates vary, the submission of these values is generally resorted to for the purpose of securing an average rate covering all the floors, the object being, that the insured may have without paying the highest rate, one policy covering all the floors.

A *short rate* is really a part of the regular rate and is that part taken for a period less than one year. If the annual rate is one dollar, the short rate for one month is twenty per cent of that, or twenty cents. This is set forth in the short-rate tables.

Early History. Early in the sixteen hundreds some of the tenants of a Count Ollendorf, in Germany, proposed to him that he should establish a fund to which they might all contribute at the rate of one dollar for each one hundred dollars of value, this fund being for the purpose of repairing any damage that might arise from fire. The Count did not embrace the opportunity, and thus,

TABLE II

Rates Based on Property Value

Money	Insured for 1 year			Insured for 2 years			Insured for 3 years			Insured for 4 years			Insured for 7 years		
£	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
10	0	0	7¼	0	1	2½	0	1	9¼	0	1	11½	0	3	0
20	0	1	2½	0	2	5	0	3	7½	0	3	11	0	6	0
30	0	1	3¾	0	3	7½	0	5	5¼	0	5	10½	0	9	0
40	0	2	5	0	4	10	0	7	3	0	7	10	0	12	0
50	0	3	0	0	6	0	0	9	0	0	9	9½	0	15	0
60	0	3	7¼	0	7	2½	0	10	9¾	0	11	9	0	18	0
70	0	4	3	0	8	6	0	12	9	0	13	9	1	1	0
80	0	4	10	0	9	8	0	14	6	0	15	8	1	4	0
90	0	5	5	0	10	10	0	16	3	0	17	7½	1	7	0
100	0	6	0	0	12	0	0	18	0	0	19	6	1	10	0
200	0	12	0	1	4	0	1	16	0	1	19	0	3	0	0
300	0	18	0	1	16	0	2	14	0	2	18	6	4	10	0
400	1	4	0	2	8	0	3	12	0	3	18	0	6	0	0
500	1	10	0	3	0	0	4	10	0	4	17	6	7	10	0
600	1	16	0	3	12	0	5	8	0	5	17	0	9	0	0
700	2	2	0	4	4	0	6	6	0	6	16	6	10	10	0
800	2	8	0	4	16	0	7	4	0	7	16	0	12	10	0
900	2	14	0	5	8	0	8	2	0	8	15	6	13	10	0
1000	3	0	0	6	0	0	9	0	0	9	15	0	15	0	0

perhaps, missed the chance of being known as the first underwriter. It has already been noted that Barbon in London established the first fire-insurance office on a commercial basis. The rates of insurance that were charged by Barbon are not known, for no records have come down to us. Tables compiled by his immediate successors have descended and these furnish exact information from that time on. It would be interesting to know how the pioneer in fire insurance solved the problem of determining the charge that should be made for the indemnity offered. One fact has come down and that is that the first rates of insurance were based, not on the actual value, but on the rental value of the property. Table I, the oldest table known, showing the rates based on rental value, was published by the Insurance Office for Houses on the Back Side of the Royal Exchange. The table is dated September 16, 1681, or fourteen years after the first office was set up.

Taking as an illustration the amount charged where the rental value was twenty pounds, for seven years the charge was two pounds and ten shillings. The plan of basing the rate on the rental value did not last for many years. In 1700 the Fire Office published another table, Table II, based on the value of the property.

Another change had crept into the method of insurance by this time; whereas previously policies were not issued for less than seven years and from that period up to twenty-one years, in 1700 they were issued for one year and for any number of years thereafter. Buildings only were insured at this time, and it was customary to give a discount, so to speak, where property was insured for a longer period than the shortest term. Thus property insured for twenty-one years would be insured for twice the seven-year rate, and so for various periods. Previous to the insuring of the contents, when buildings only were insured, rates were divided into two classes, those for wood buildings and those for brick or stone. It is important to remember that there never was a time when all property was insured for the same rate. Discrimination, according to construction, began with the business and has continued ever since, growing more and more refined as knowledge has become more exact. The amount charged for the insurance of contents, when in 1706 the Sun Fire Office, or rather the founder, .Povey, commenced to insure contents, was the same as the rate of the building. If the contents were in a wood building, the rate for the wood building was charged; if in a brick or stone, then the rate for brick or stone.

Group System. The business then moved forward to the next step in 1714 or 1715 when the Union Fire Office introduced a system of classifying or dividing risks into groups, which has prevailed in a large measure even down to the present time. It is evident that when the insurance offices began to experience real fires, attention would be drawn to the fact that property occupied by certain businesses had more fires than that occupied by others. Insurance could not long have continued without acting upon this information. If the existing offices had not taken note of it, new ones would certainly be established that would. It seems to be fairly well established, however, that the Union Fire Office, founded in 1714, was the first to introduce the distinction of hazardous and doubly hazardous risks. They really had three classes, the first being called *common*, the second *hazardous*, and the third *doubly hazardous* insurance. To make further modification, the directors were empowered to divide these classes into one-quarter, one-half, and three-quarters of the rate in the next class when they were convinced that the risk did not fall into the lower class. This classification is in use to a certain extent in Great Britain today and the same is true in the United States, although in this country it has more completely passed away since the system of schedule rating is so largely in force. It has been superseded in Great Britain where the "special tariffs" as they are called, apply, but it is still in force in mercantile properties and in the less hazardous risks.

Special Hazards. About this period certain trades being deemed more than usually risky were placed in a class by themselves, as brewers, distillers, ship and tallow chandlers, etc. They naturally took higher rates. Another practice that prevailed in the early history of the business was the practice of increasing the rate of insurance if the amount insured passed beyond a certain sum. This practice in Great Britain was quite general, lasting down to the commencement of the nineteenth century. In the United States it appears never to have been adopted.

This outline is sufficient to acquaint the reader with the methods of determining the rate of insurance which prevailed down well into the eighteen hundreds, probably 1820 at least. It was, as can be seen, nothing more than a simple rough grouping of the different classes of business and then the application of certain rates to those groups. At the utmost, the number of classes could not have been more than eleven, that is, one for frame or wood houses, for brick or stone houses, for common, hazardous and extra hazardous insurance, with the division into fourths, halves, and three-fourths between common and hazardous and between hazardous and extra hazardous. Hence the rater of that time or the underwriter since the specialization had, of course, not then originated, had from the report on the property merely to determine into which class it fell, and the rate was known.

Wool Tariff. In the year 1848, the first of the seventeen tariffs now in use in Great Britain for rating different classes of property was adopted. This first tariff, as it is called, applied to wool mills. These tariffs, or schedules, as they are called in this country, make an attempt to analyze the construction of the property and the various hazards entering into its occupancy and to fix a charge against each one of these. They naturally began with business which was highly specialized, as in the case of the wool mills in Great Britain, and from time to time as business has developed and reached the point where it was worthy of special attention, the tendency is to adopt a tariff for it. Some seventeen of these now apply in Great Britain, the last having been adopted in 1906.

METHODS IN THE UNITED STATES

In the United States, the methods of Great Britain were naturally followed in the beginning. The Philadelphia Contributionship, the second mutual association that insured houses, adopted the minimum period of seven years, which was the minimum in Great Britain for a long while, and charged twenty shillings for one hundred pounds if the building were brick, and sixty shillings if it were wood. There was nearly always—and the practice has not wholly passed away—a requirement that there should be a charge for the policy itself. In Philadelphia companies, this was one shilling and twopence for brick, and two shillings and sixpence for frame. An interesting bit of rating history is connected with the third mutual association organized in this country. It was commonly known as the Green Tree Company. A fire having occurred in a certain property, it was transmitted by means of trees in front of the house to a building insured by the Contributionship. The trees not only transmitted the fire, but hindered the firemen in their work. The Contributionship thereupon voted to notify all members that their insurance would cease unless the trees in front of their houses were cut down. Several members rebelled and endeavored to have the rule rescinded, threatening to withdraw unless this was done. The Contributionship would not change the rule, the members withdrew, forming another company which was the Green Tree Company. This company then made a special rate for those members who had trees in front of their houses, adding a special charge, in addition to the regular charge, for the presence of trees. This is undoubtedly the earliest instance in the United States that history records of a special charge for a distinct hazard.

So far as known no investigations, with one exception, were made concerning losses, indeed it is doubtful if in the beginning of fire insurance in this country, it would have been possible except in a very limited field to have gathered statistics of losses by fire, which would have been of any value. In 1797 when the Mutual Fire

Insurance Company of Boston was organized they made extensive researches, running back for a period of thirty-eight years showing the number of buildings that had been destroyed by fire in that time. The data collected showed that throughout the period an average of three thousand buildings constituted the then town of Boston, and in thirty-eight years the losses were eighteen per cent. But insurance had been established for some years prior to this investigation and the pioneer was obliged to feel his way or go by rule of thumb.

Fixed Base Rate. The earliest offering of stock fire insurance upon the basis of a fixed rate (meaning other than assessment or contributionship insurance) was in 1794, and the company's proposals embraced the division of buildings into four classes, each carrying a different rate, and the division of contents into four grades, three of which carried a charge to be added to the building rate, thus:

BUILDINGS:

(I)	Brick or stone, covered with slate, tiles or metal	50 cents
(II)	Brick or stone, covered with shingles	60 cents
(III)	The sides in part of brick or stone and in part of wood	70 cents
(IV)	The sides entirely of wood	80 cents

CONTENTS:

Not Hazardous:	At same rate as building	
Hazardous:	Add to rate of building	12½ cents
Extra Hazardous:	Add to rate of building	25 cents
Special:	Rate to be specially agreed upon, but add to building not less than	50 cents

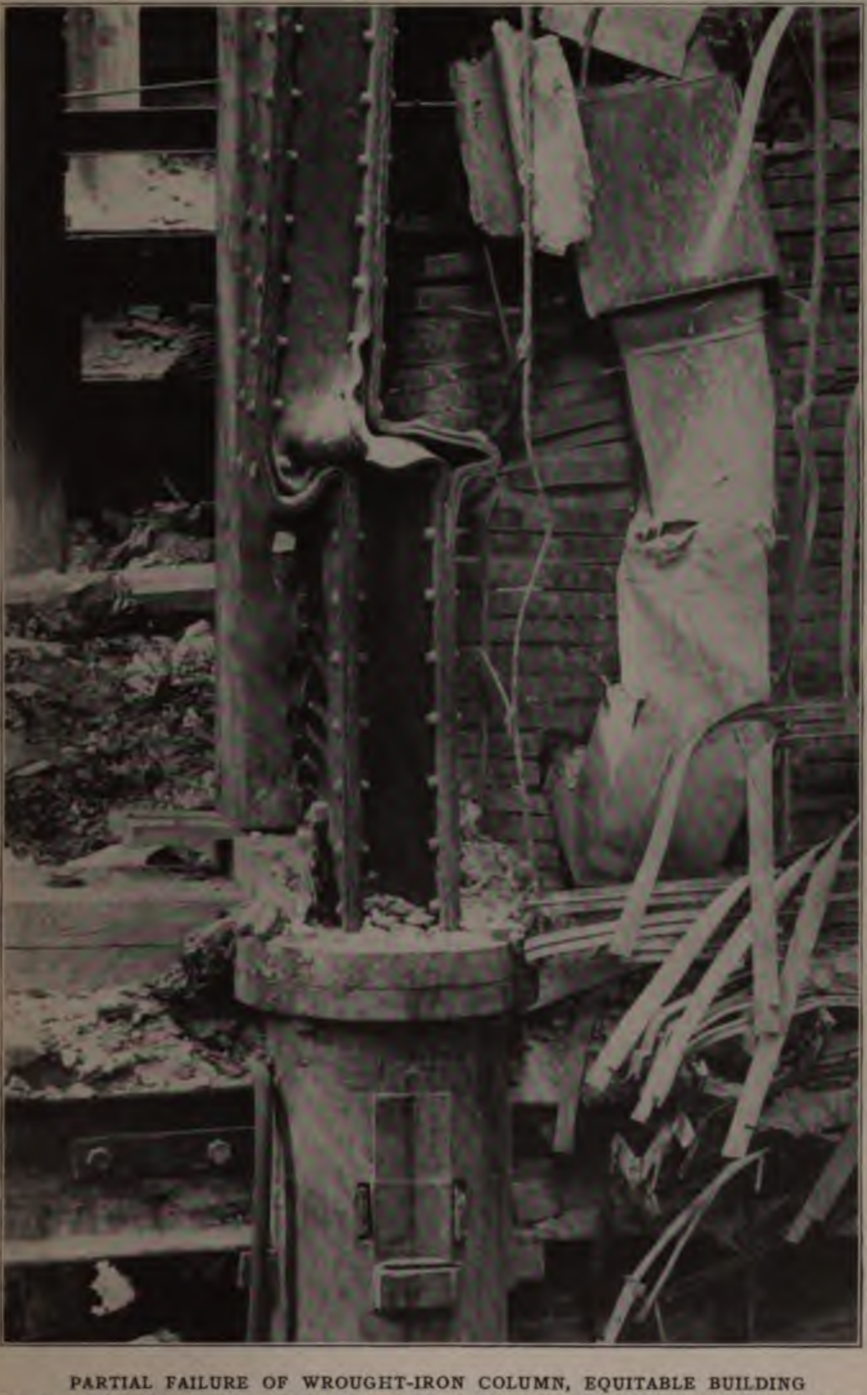
This was not quite so simple as the uniform policy and uniform premium of 1710 in England, but still it appeals to one as having been within the easy mental grasp of the policyholder. His building fell readily within one or another of the Classes of Hazards, and having once landed there, its rate was ready for it. His personal property fell almost as readily into one or the other of the contents classes, and forthwith a charge was presented to be added to the rate of the building containing the goods. Buildings then stood largely detached, or at least they did not touch their neighbors, elbow to elbow; there was always some space all around them. Men had their individual shops or places of business as they had their individual homes or dwellings. The day of the mixed or omnibus hazard had not arrived.

Classes of Hazards. Very soon, however, the idea of further differentiation in classes of hazards for buildings began to develop with the result that the Massachusetts Fire Insurance Company, in 1798, put forward six, three of them corresponding to I, II, and IV of those named in the preceding paragraph, but with the qualification added in each case that the buildings should stand separate from other buildings, or, if adjoining, that they should be separated by brick partition walls; and three new classes were made to provide for the others where such separation by brick walls did not exist.

In 1820 a classification was put forward in New York (very likely as the result of the deliberations of the "Salamander Society" composed of the eight companies then doing business in that city) which embraced eight building classes, beginning with "buildings of brick or stone covered with tile, slate, or metal, the doors and windows of solid iron," and ending with "buildings entirely of wood." In passing, we may note that the expression "covered with" is used as we might refer to the cover of a pan or kettle, and means "roofed with", and the requirement of "doors and windows of solid iron" must not be taken literally; later they became familiar as "iron doors and shutters", and in the end signally betrayed the faith reposed in them.

For the sake of comparison, and because at this time the Classes of Hazards seem to have reached a fairly complete development, the eight classes referred to as set forth in policies of 1820 are shown, viz:

First:	Buildings of brick or stone, covered with tile, slate, or metal; the doors and windows of solid iron. . .	30 cents
Second:	Buildings of brick or stone, covered with tile, slate, or metal	35 cents
Third:	Buildings of brick or stone, roofs three-fifths of tile, slate, or metal, the rest shingled	40 cents
Fourth:	Buildings of brick or stone, covered with wood . . .	45 cents



PARTIAL FAILURE OF WROUGHT-IRON COLUMN, EQUITABLE BUILDING
This Shows the Effect of Extreme Heat. Note Method of Fastening Wrought-Iron Beams to Cast-Iron Columns by Straps Passing Through the Column, Shown Broken Off at the Bottom of Picture
Courtesy New York Board of Fire Underwriters

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Fifth:	Buildings of frame, filled in with brick, with front entirely of brick	50 cents
Sixth:	Frame buildings, filled in with brick	60 cents
Seventh:	Frame buildings, hollow walls, with brick front	70 cents
Eighth:	Buildings entirely of wood	80 cents

NOTE.—Country houses, standing detached from other buildings, though of the sixth, seventh, or eight class, will be insured as of the fifth class.

The classification and charges for contents as set forth in policies of that year are also given in full as follows:

NOT HAZARDOUS:

Goods not hazardous, are to be insured at same rate as building in which they are contained, and are such as are usually kept in dry goods stores, including also household furniture and linen, cotton in bales, coffee, flour, indigo, potash, rice, sugars, teas, spices, paints ground in oil, threshed grain, and other articles not combustible, and not hereafter enumerated.

HAZARDOUS:

The following trades, goods, wares, and merchandise are considered hazardous and are charged 12½ cents per $100 in addition to the premium for each class of buildings, viz: Booksellers' stock, chair makers, chocolate makers, confectioners, china, glass and earthenware in packages, flax, hemp, jewelers' stock, milliners, musical instrument sellers' stock, oil, pitch, pictures and prints, sail-makers, ship chandlers, spiritous liquors, saltpetre, tar, turpentine, tavern-keepers, tobacco manufacturers, and watchmakers' stock.

EXTRA HAZARDOUS:

The following trades and occupations, goods, wares, and merchandise, are deemed extra hazardous, and will be charged 25 cents and upward per $100 in addition to that premium for each class, viz: Aqua Fortis, apothecaries or druggists, boatbuilders, coach-makers, cabinetmakers, carpenters in their own shops or in buildings erecting or repairing, china, glass, or earthenware unpacked, and buildings in which the same are packed, coopers, dyers, ether, founders, fodder, and grain unthreshed, hay, musical-instrument makers, spirits of turpentine, straw, soap boilers, and tallow chandlers, and all manufacturies requiring the use of fire heat. Gunpowder is not insurable unless by special agreement.

SPECIAL:

Bakeries, breweries, printing offices, book-binderies, chemical laboratories, distilleries, malt houses, grist mills, saw mills, paper mills, sugar refineries, and other manufacturing establishments, will be insured at special rates of premium.

It will be seen that the requirement of isolation from other buildings, or, if adjoining, their separation by means of brick walls, is not made in this classification, but upon the safe assumption that such isolation or separation was meant to be understood, then eight more classes would have been required to care for the instances where isolation or separation did not exist.

So far, classification and rates had been upon broad group-divisions and upon lines of demarcation easily applied. During the next twenty years, however, the idea of closer subdivision and greater differentiation of the individual risk evidently gained ground, for, in 1839, in a tariff of rates issued for New York City a list of deficiency charges is set forth to be imposed in rating warehouses and stores which may be taken as forerunners of the schedule charges imposed today. Thus, there was a fixed rate of 30 cents for a brick building occupied as a store or warehouse; not exceeding 40 feet in height; having tile, slate, metal, or cement roof; with brick, stone, or metal gutters; solid iron window shutters; no dormer windows or skylights; and situated upon a street not less than 50 feet wide; and to the rate for this standard building additional charges were required to be made for deficiencies in any of the particulars named, the streets being listed by name, and a charge fixed upon each running from 4 cents to 28 cents according to its variation from the standard width required.

Beginnings of the Schedule System. The simple group system began to disappear, and the foundation of the complex schedule system developed in its place; and with the latter the idea of separately determining the underwriting results upon the classes producing them also sprang into life. Both grew steadily for the next twenty years, and in 1860 there were in use special surveys for various kinds of manufacturing risks, such as cotton mills, wool mills, paper mills, flour mills, tanneries, and so on. So, too, in time appeared a classification ledger providing for debit and credit accounts with some eighty-five classes of risks, by the use of which ledger it was assumed that head offices would be able to show just what classes were profitable or the reverse. This marked monumentally the change from the group system to the class system, and it has been faithfully followed up by many companies even to the present day, the number of classes being enlarged to keep pace with building methods and the development of trade and manufacturing, so that in at least one classification used today there are 1,600 classes, with new ones being added from time to time.

A more reasonable one, and which is nearer the average of those in general use, shows 244 classes, which are divided into five groups, namely: "Non Hazardous" covering 60 classes; "Mercantile" covering 40 classes; "Manufacturing Specials" covering 90 classes; "Automatic Sprinklered Risks" in 10 classes; and "Non Manufacturing Specials" in 44 classes. Each class is divided into brick and frame, and is designated by numbers, the odds all being brick and the evens frame; and each is further subdivided into protected and unprotected business, a protected risk being one located within 500 feet of a hydrant connected with a town or city system of water works, and all risks not so located being considered unprotected. Not only is the business of the company classified as a whole, but by states and individual agencies, so that its experience can be shown for localities as readily as for the entire country. It must be borne in mind, however, that every company makes its own classification and that there is no method recognized as standard; consequently there is no possibility of bringing results together upon a uniform basis.

Before turning to schedule rating, which is the great modern method of rating, it would be well to note the average rate of insurance, meaning thereby the sum represented by dividing the total premiums charged by the total risks assumed. This lumps together, of course, premiums received from buildings, contents, and every form of insurance against fire. From 1871 to 1880—94 cents, 1881 to 1890—98 cents, 1891 to 1900—$1.03, 1901—$1.06, 1902—$1.15,
—$1.18, 1904—$1.16, 1905—$1.16, 1906—$1.14, 1907—$1.16,
$1.14, 1909—$1.12, 1910—$1.08.

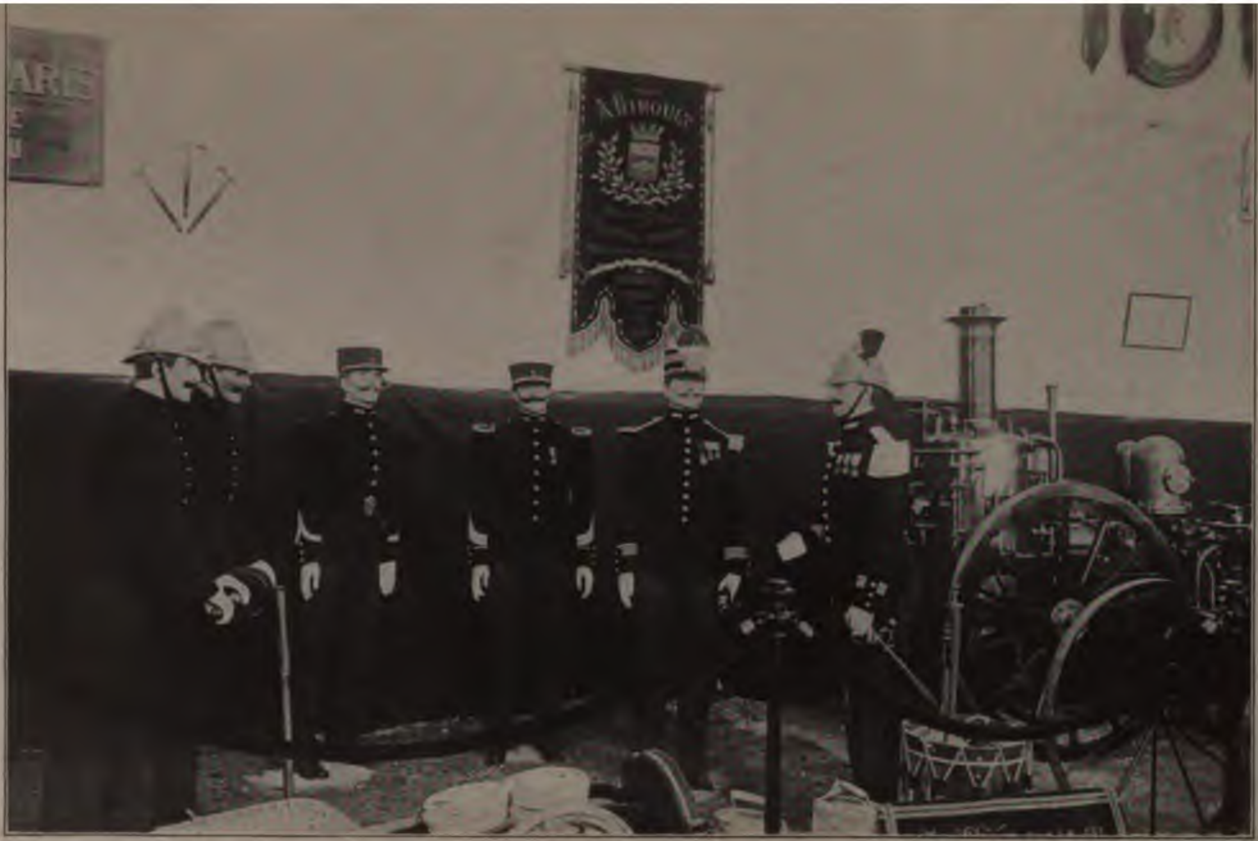
It is worthy of note that the rate is lower today than it has been since 1901. This period embraces the Baltimore conflagration of 1904, with an insurance loss of $40,000,000, and San Francisco, 1906, with an insurance loss of $163,000,000. These statistics clearly show that there are no wide fluctuations in the average rate of insurance.

SCHEDULE RATING

The modern system of schedule rating which is practiced throughout the world had its origin in England and the first tariff was applied, as the work is called, to the cotton mills. This industry was among the earliest to have individual plants and to furnish an opportunity for studying the causes of fire, or the hazards as they are called in connection therewith. Some seventeen of these different schedules, or tariffs as they are called in England, have been adopted since the one for cotton mills. In the United States the cotton-mill tariff was early adopted, probably in the fifties, and by modification was made to do duty for other types of mills. The great impetus to schedule rating in the United States was furnished by the organization of the National Board of Fire Underwriters in 1866. The National Board was proposed in April, 1866, and to the call sent out by the committee requesting those who favored such an organization to meet in New York City in July, a sufficient number of favorable replies were received previous to the Fourth of July of that year. On that date occurred the famous fire in Portland, Maine. This fire emphasized the necessity for co-operation and was no doubt quite influential in making the early success of the National Board.

Previous to this organization there had been bodies covering lesser fields, and some attempts at a national organization. This was true in 1826, also in 1852.

National Board. Whatever else the National Board tried to do in its beginning it attempted a comprehensive system of rating. The plan in brief was a division of the country into districts, the formation of local bodies for these districts, the business of the local bodies being to make rates according to the rules and schedules adopted by the National Board. It is sufficient to state without going into the causes that the plan of working from one central source did not prove feasible. The final authority was too far removed



EARLY TYPES OF UNIFORMS USED BY FIREMEN IN PARIS

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to handle local problems in that way. The insurance people themselves and the community were yet to be educated up to the wholesomeness of schedule rating. Like all great movements the success in the beginning was remarkable. Competition, however, for business threatened to bring the entire experiment to a close when there occurred in 1871 the Chicago fire, followed a year later by the Boston fire. These two disasters forced for a time at least a co-operation between the companies and an allegiance to their agreements which was unquestioned. It was a case where, in the words of Franklin, "they must hang together or hang alone." The companies that survived the two great fires found themselves with such depleted resources as to make impossible, even if it had been advisable, a competitive strife. Later on as new companies were formed in the United States and foreign companies commenced to enter the country it was found that to attempt to rate from a central organization, however ideal it might be, was a practical impossibility. The agents in the local centers were able to persuade their chiefs that the rate must be determined by someone more familiar with the facts than a body as far distant as the National Board. The existence of the board was threatened by the problem of rating. They very wisely abandoned that field of activity, since which time the Board have done most admirable work in dealing with the other matters which vitally affect the business of fire insurance.

RATING ORGANIZATIONS

After the abandonment of its rating duties by the National Board, rate making passed to what might be called *local bodies* and there it stands today. The phrase, local bodies, must not be taken too literally. Perhaps the expression, bodies smaller than national, would more perfectly convey the meaning. In the larger cities—New York, Philadelphia, Chicago, Boston, St. Louis, Louisville, and others, the problem of rate making is handled by the agents or companies there doing business. In the New England states outside of Boston, all of New England is taken care of by one organization with the exception of the cities of Providence and Hartford. In those parts of the country less thickly settled an organization may cover several states as the Rocky Mountain states, the Pacific Coast states, or the southern states.

No forms of organization have been so subject to attack as the organization for determining the rate of insurance to be charged; particularly in the western and some parts of the southern states, the attack has been most bitter. Curiously enough, it has been most severe where the least property was at stake. In the large cities of the East the organizations have been permitted almost without disturbance. The necessity for their existence has been more evident to the business interests of the large cities than to those business interests which are represented by scattered communities.

Duties of Rating Organizations. A rating organization is one whose duty it is to inspect properties which are offered for insurance within the territory in which it operates, to determine the rate to be charged, and to decide on the general rules and practices that shall control, in order that the purpose of the organization may not be defeated. Until about 1910 none of these organizations were more than gentlemen's agreements. Their success or the adherence to the rules depended entirely on the good faith of the members. The same is true today with the exception that in the states of Kansas, Texas, Louisiana, Missouri, and New York there has been established by the legislatures, a state supervision of the rating organizations. In Kansas all rates must be filed with the superintendent of insurance and no departures or changes may be made therein unless the same are filed with the superintendent. In Texas a state rating board has been established on which, of course, the companies are represented and this board exercises the same powers as the superintendent in Kansas. In Louisiana a law takes effect in about one year and is practically a copy of the Texas law. In the state of New York on September 1, 1911, the law took effect which vests in the insurance department the right to examine at any time rating organizations, to review cases where the insured are dissatisfied, and, in fact, to exercise a somewhat complete power of review of the workings of the organizations. If this power is not sufficiently strong to enable the superintendent of insurance to accomplish what he thinks necessary to properly guard the interest of the insured he can in his annual report to the legislature recommend and doubtless secure such additional powers as may be necessary.

Methods. There appear to be three methods of conducting business. The first and oldest is the competitive, where the interest of the seller in his desire to secure the trade of the buyer leads him to sell at the minimum cost. With this method the state does not interfere. The second method to secure trade is the method of the trust which aims to control production and thus compel the buyer to trade with them. This method the state absolutely prohibits. The third method or rather group of corporations represented by the insurance companies and public service corporations are those where the commodity sold is of such a nature that the practice of fixing the price co-operatively seems to have good grounds for existence. To prevent this rising to an oppression since competition in price is prohibited, the State says, we will permit you to do this but reserve to ourselves the right of review as to your actions on appealed cases. The New York act represents this third attitude in perhaps its best manner. The Kansas, Texas, Missouri, and Louisiana attempts are more drastic and time alone will tell if they are to be successful.

Justification for Rating Organizations. But the interesting and fundamental question remains to be answered, and that is, why should it be necessary for the insurance companies to agree by mutual consent as to the price which they will charge for the thing which they are selling. The primary reason lies in the simple fact that the thing which the company is selling, namely, indemnity, is not something which they have bought at a certain price and have this price on which to base their selling price.

The insurance loss varies from year to year, not only as a whole but very markedly in certain classes of business. No one company has on its books, outside of the small number of simple uniform hazards, sufficient experience on which to determine the proper charges to be made. A grocer when he buys potatoes knows what they cost him and how much he must sell them for to gain a profit. Insurance lacks that solid rock. In the early days of the insurance business before the conflagration hazard was well understood and before properties had grown to such a size as to demand anything like the amount of insurance necessary today, the companies did not hesitate to take what would be considered very large lines. Fifty years ago it was a rare thing for a merchant to desire or have need for much over fifty thousand dollars of insurance. Today, single business enterprises, such as department stores, in single blocks, or even less, call for insurance of three to five millions of dollars. Such cases exhaust the insurance market of the world. Now it is evident that with enterprises that call for all the insurance that can be furnished by one hundred and fifty or more companies, if each company were to compute the rate to be charged individually it would mean the doing of this as many times as there were companies insuring the risk. Hence, primarily the rating organization is an economic one. It does for all the companies by one operation what each company would have to do for itself if it were not for this co-operative manner of computing rates. It must be borne in mind always that insurance is in a sense a tax, hence, whatever increases the cost of the tax makes that much more of a burden to those who are obliged to pay the tax. Fire insurance is not a luxury to be bought only by those who may wish to. It is a necessity. Under our modern system of business, it is fairly safe to state that but a very small proportion of property subject to loss by fire and which can be insured, is not insured. The community, therefore, has a direct interest in keeping every item of expense which enters into the business at as low a point as possible.

Another reason for permitting the rate of insurance and other practices to be determined by co-operation is the fact that our modern method of private fire protection is based very largely on the difference in rate of insurance that is granted for the installation of the devices. The equipment of a certain group of piers with sprinkler protection means an expenditure of something like one hundred thousand dollars. Before proceeding with this work the parties in interest always consult with underwriters to ascertain the rate of insurance that will be granted after the device is installed. If it were necessary to consult with one hundred and fifty different bodies in place of one, the entire system of modern private fire protection would pass away. That of course cannot be permitted since it would absolutely stop certain important businesses and add appreciably to our already heavy fire loss.

It should be pointed out that the rating organization does not in any sense control the underwriting policy of any of the companies represented in its membership. A company may or may not choose to write a risk. As a rule strong competition exists for the securing of the business by the different companies outside of the congested spots in the cities where the conflagration hazard is deemed dangerous.

The state, however, undoubtedly is exercising a wise policy in saying to its citizens that, while these corporations are permitted to exercise some of the powers which are those of a trust, the State in its power of review will see to it that these trust features are not permitted to become oppressive in any way. There shall be allowed the companies a reasonable liberty of action but not an unbridled license.

Work Distinct from Insurance Companies. In connection with rating organizations there is a tendency and a growing one to separate the work of rating from a too close company control and to place it in the hands of those who have made a special study of the problem. This movement started, largely owing to political considerations, in the western part of the country. It has not extended to any of the eastern states to a great extent, although nearly all those engaged in rating today have devoted themselves more or less steadfastly to this branch of the business. It was not a difficult matter sixty years ago to make a fair guess at what the rate of insurance ought to be on the ordinary five-story building. It is quite a different matter, however, when the problem presented is to determine the rate on the Woolworth building now being erected in New York City. This will rise seven hundred and fifty feet in the air, being the tallest structure erected by man with the exception af the Eiffel tower in Paris. It represents an investment of thirteen millions of dollars, of which eight millions will go into the structure above the foundations. Back of all this there must be an insurance policy or the investment would not be made.

Executive Organization. *Officers.* Under whatever name the body may be called, the rating organization does not differ essentially in the different parts of the country or in the world for that matter. As the organizations do not operate under a charter or under the law except in a remote manner, their success depends upon the utmost good faith in the members toward each other and a keen respect for the rates and rules which have been adopted. The articles of the organization are generally termed an agreement. This is signed by the executive officer of the company in the territory to which the agreement applies and by the local agents operating therein. Owing to the large number of companies incorporated in the state of New York, naturally more company officers are represented in the organizations there than in other states where the membership is more largely made up from the agents who represent the companies of other states. The officers consist of president, vice-president, secretary, and treasurer. There are committees who discharge duties between the sessions of the main body and who have, of course, full jurisdiction on many points.

Committees. The usual committees are: a committee on rates, a committee on brokers or agents, an arbitration committee, and an executive committee. The executive committee discharges the duties which have primarily to do with the business of the organization. The rate committee handles those problems which deal with rates. The brokerage or agency committee deals with those questions which arise concerning these parties, while the arbitration committee is in a sense a court which hears and passes on cases in dispute and which do not more strictly fall within the province of the other committees. Whatever the names of the committees the above represents about the kind of labors which they are called upon to perform. The city of New York, which is the only city in the United States where there is a large class of individuals, several thousand, who devote themselves to the brokerage business, furnishes the committee dealing with those problems a large amount of work. The rate committee is a body to which an appeal is taken for any question concerning rates in which the party does not feel satisfied with the decision of the office, and should the party not be satisfied with the decision of the rate committee, he may then appeal to the main organization itself at its regular session. The latter, however, is something which is very rarely done. Almost every case that arises and which can be settled by a committee, is usually settled by such committee.

The arbitration committee finds its chief work in passing on those cases where complaint has been made that a policy has been issued at a wrong rate or by permitting a privilege which is not allowable. This committee is usually empowered to fine offending members a certain amount generally based on the magnitude of the offense or according to the amount of the insurance written. The organization has adopted certain rules, which rules are presumably in the interest of all. Their infraction if permitted to go uncorrected would lead to the disruption of the body. The breaking of the rules may not be, generally is not, intentional. It is more often due to the misinterpretation of the rules by an employe. But naturally it would not do to permit that plea to be an excuse for a non-enforcement of the rule; it would be impossible to distinguish those cases where the breaking of the rule was unintentional from those cases where it was intentional.

Working Force. The officers of the organization are parties to the agreement but the working force who do the rating and the work necessary thereto are all employes and naturally forbidden to have any interest in the business of writing or placing insurance. The head of the body is generally called the manager or secretary. There may or may not be an assistant manager or secretary. The working force will be divided into the following departments—the inspection department, the rating department, the information department, the correspondence department, the sprinkler department, and the licensing department which deals with brokers and agents.

The *inspection department* is charged with the work of inspecting, or surveying as it is often called, properties which are subject to specific rating.

The *rating department* takes the reports made by the inspectors and determines the proper rate applying under the rules to the risk. The inspector, in some cases, does the usual work of an inspector and in addition makes the rate. Better results in the more congested cities have been produced by having the rate computed by a separate body of men. A person who has not visited the risk may apply the schedule in a more cold-blooded manner than one who has visited the property and is affected more or less by what he has seen. But where the rate is applied by a different person more just rating is undoubtedly secured over a large series of properties.

The *information department* is an important bureau of the rating organization. It handles a hundred and one questions that arise, even when the business has been reduced to as much of a system as possible. All rating organizations today furnish the insured with a copy of the rate as it is computed by the office. When this is received by the insured, or his broker, or agent, some questions will naturally arise thereunder. In many cases the parties for the purpose of having a record will write about the matter, but in ninety per cent of the cases the representative will call at the office and have the matter explained.

The *correspondence department* will handle all communications other than those which will be taken care of in due course by each individual department.

There is another important department connected with some organizations whose chief purpose is to see that rates and rules are properly enforced. This is a *policy-checking department.* To this department all policies before being delivered to the insured are sent to be checked. Should the rate be incorrect or should there be any other deviation it is returned for correction before being approved.

The expenses of the rating organization are divided amongst the members by means of an assessment, which assessment or tax is levied against the individual member according to the premium receipts of that member in the territory. There may be other sources of income from membership fees but the principal source of support comes from the assessment.

One of the most important functions of the organization in its effect, not only on fire insurance but on fire waste, is the fact that it stands ready at all times to furnish to the insured or his representative the information, suggestion, or advice that will in any way assist in reducing the rate of insurance by the installation of fire-fighting appliances, by suggestion for the removal of the conditions which cause fires, and even pointing out how the rearrangement of the plant may be better for all parties concerned. It is a mistake to suppose that the so-called high rated properties are desirable, as a matter of fact they generally are not. The better risk well protected and well cared for with a lower rate of insurance is at all times the more desirable property to insure.

THE MAKING OF A SCHEDULE

While considered of comparatively modern origin, schedule rating as a matter of fact really began with the business of fire insurance. The mere fact that the first underwriters made two sets of rates, one for wood and another for other kinds of buildings showed

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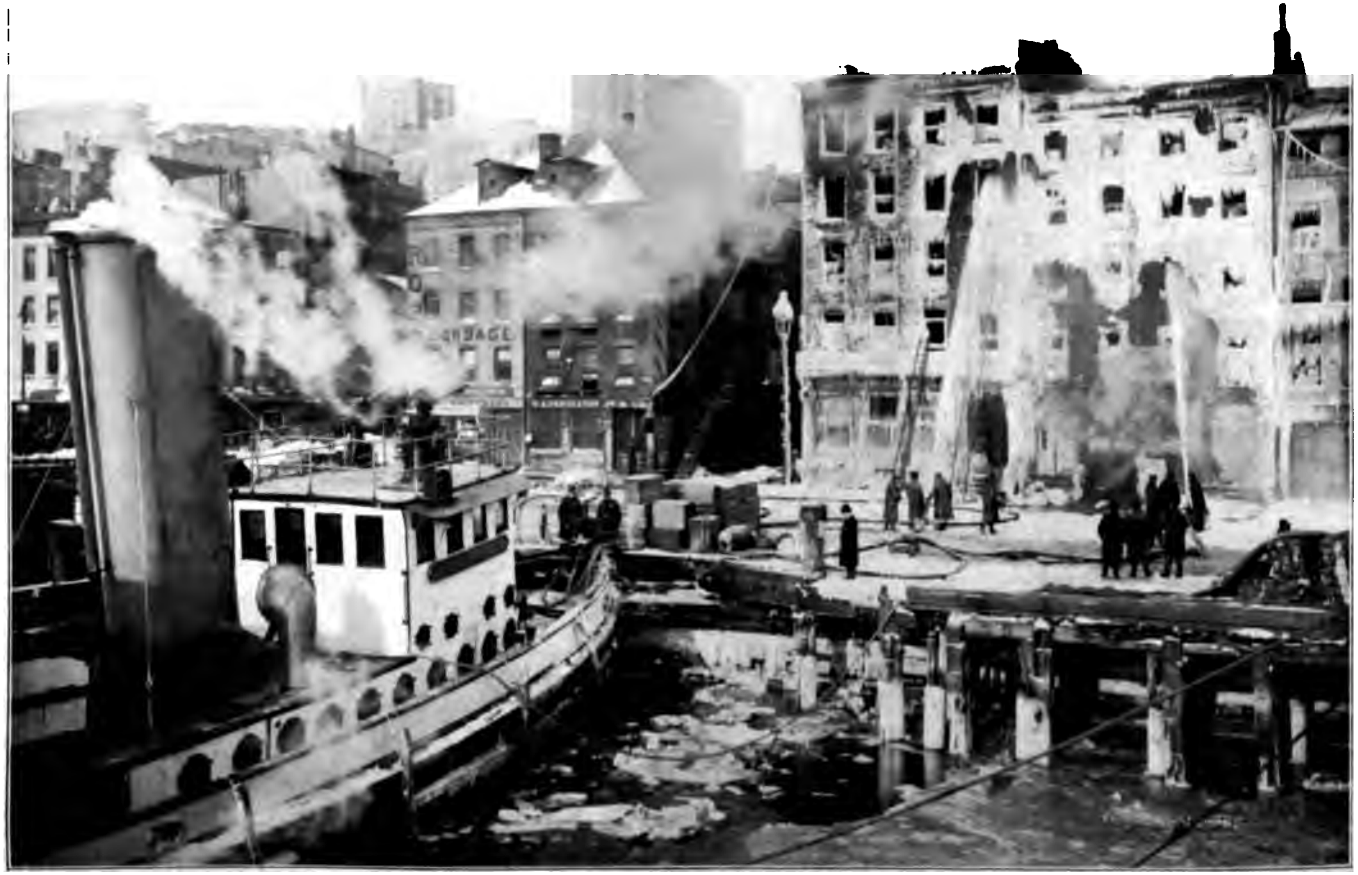

WATER FRONT FIRE, NEW YORK CITY

a discrimination between the only things then considered in the rate of insurance, namely, the construction of the property. The whole process from that time forward down to the present day, and it is still going on, has been simply a refining of what the early underwriters started. At the same time the refining process has been so developed within fifty years that it is a safe statement that the underwriters previous to that date had no conception of schedule rating as it is understood today. The phrase *schedule rating* was probably first used in the latter part of the sixties in the United States.

A *schedule* may be defined as a method of assessing the insurance tax by computing this tax by means of a series of charges, which charges shall have the effect of penalizing those factors in a property which are known to cause or increase the fire loss, and crediting those factors in a risk which are known to be helpful in preventing or retarding fire loss. There have been many schedules put forth since the work was started. After the breakdown of the attempt to have schedule rating done by one central body for the whole country, the work of rating fell to bodies representing minor divisions, though some of them represented several states. The tendency was for each group of underwriters to devise schedules which they felt peculiarly met the condition of their territory. Furthermore, when it was started the transmission or interchange of information from point to point was much slower than it is today. Most businesses were local and all problems were handled from the local point of view. There naturally was a feeling that the local representatives were much better acquainted with the special problem in their neighborhood than any outside body could possibly be. Inasmuch as the business which the company secured came from these local representatives they were somewhat slow about antagonizing them in this matter. The same condition of affairs, that is diversity, exists to a great extent today. This is due, however, to the fact that it takes years to work out the peculiar problems of any one section. And when this has been done in a manner fairly satisfactory to all interests concerned, it will require something like an upheaval to change the settled conditions. The application of a new schedule means that the agent and the insured must both be educated to its use. The agent must defend it while the insured who has become accustomed to the old manner will naturally resent any changes unless it means a lower rate of insurance. A reduction of rate, the insured can always understand. It is when the rate is increased that there is trouble in furnishing an explanation which will appear just to the party affected.

It must not be inferred from what has been stated that rates today are made wholly on schedule. There are many cases where the old system of flat or judgment rates as they were termed are still enforced. Such methods, however, are passing away rapidly and, with the exception of dwelling properties, in all probability will pass away entirely in time. Two attempts have been made to produce schedules capable of universal application, both of which have received a very wide recognition. The first of these, the "Universal Schedule", is fully considered in Rating, Part II; the second, the "Analytic System", will be treated in Rating, Part III. Before proceeding to take up the Universal Schedule it will be best to proceed from the simplest example of rating and by a series of stages advance to the somewhat intricate problem represented by the "Universal Mercantile Schedule."

"Minimum Rate" Risks. A minimum rate, as the phrase is commonly used, means a rate which applies to a large group of risks which, owing to their uniform hazard, it is not necessary to consider specifically. All of the rate books have a list of minimums which are used by the companies in writing insurance within the territory to which they apply, if the risk is not under the terms and rules subject to a specific rate.

Private Dwellings. The most common type of minimum rate is the private dwelling. Probably 90 per cent of the buildings in the United States are of this type of risk. They do not, of course, represent the greatest value, but they do represent the largest number. All the other classes of buildings in the United States represented in the other tenth are normally those which are subject to what is termed a specific rating. Whenever a group of risks is sufficiently numerous and the hazard of a mild type, specific rating need not be resorted to. But when a risk departs from a mild hazard condition it is normally subject to a specific rating.

Multiple Dwellings. Multiple dwellings, those which contain more than one family, are usually all in the minimum rated class, except as they rise to a higher hazard as represented by apartment houses which cover a large area, have provision for many families, or are fireproof in construction.

Store and Dwelling Next to the private dwelling and apartment house probably the so-called store and dwelling rank in numbers as third. This is a building occupied, usually, on the first floor for business purposes, while on the upper floors it is occupied for dwellings; hence, the name store and dwellings. This type is also represented by buildings of one story in height with a store in the front and dwelling in the rear.

A private dwelling has one rate for the building and one for the contents. To this there are no additions. The rate for the building will be either two times for three years or two and one-half times, the term rule, as it is called, differing in different parts of the country with a tendency to adopt the two and one-half year rule, or as it may be better expressed—the full rate for the first year and three-fourths of this for any succeeding year or part thereof when written for more than one year. The same would be true of the household furniture.

Variations from Minimum Rate. The ordinary apartment house, either brick, frame, or fireproof, would not differ in method of rating. It would be a case of a fixed rate for the building and the household furniture. The same would be true of the ordinary store and dwelling. The private dwelling, or the apartment house, or the store and dwelling may become subject to a charge in addition to the minimum provided. This charge may be, generally is, for exposure, and the rate in that case would be the minimum rate plus the exposure charge. As soon as there has been added to the minimum rate any charge, although it be but one, the first step in schedule rating has been taken.

The store and dwelling may have as a business tenant not an ordinary store, as dry goods, groceries, etc., but the store may be occupied by a carpenter, painter, a power laundry, junk dealer, or a manufacturing business. This business occupancy may be confined to the basement and first floor, but the remainder of the property be occupied for dwelling purposes. It is not customary to consider that such an occupancy as last enumerated permits the property to remain in the store and dwelling class. It is deemed that the hazard of a painter, carpenter, etc., is far beyond that of the ordinary store. Hence, if the property is thus occupied it is considered subject to a specific rating or consideration, and a charge is made against the building and the other tenants for this increased hazard brought into the building by the business tenant. This charge is commonly called an internal exposure, meaning that the other tenants have their normal chance of fire increased by this more hazardous business. The internal exposure charge will vary according to the business. Thus, a hand-power carpenter would probably penalize a building of ordinary construction ten cents and the other contents fifteen cents. The value of a definite rule or fixed charge to govern such cases is evident, since the property owner can ascertain before renting his property to a tenant what effect it will have on the rate of insurance on the building and contents.

Methods of "Specific Rating." *Combined Occupancy.* It is a principle of rating that when for any reason a property becomes subject to a specific rating it is subject to measurement by the schedule which applies to the rating of that property. Hence, in making the inspection for the carpenter as a tenant in an apartment house the property will be examined not merely to ascertain that fact but all others which under the schedule should be charged for in the rate of insurance. Thus a property might after such an inspection, and using the building as an example, find the following charges making up its rate:

Base Rate	$ .10
Communications	.05
Internal Exposure	.10
Unsafe Gas Brackets	.10
Total	$ .35

Some of these charges, of course, are removable, and while this phase of schedule rating will be discussed more fully later, it will do no harm to point out that the gas brackets in this case can be corrected to conform to the standard and communications bricked up. Thus those two charges may be wiped out leaving only the internal, but the inspector might have developed a severe exposure against the property from another risk and this could not be disposed of so easily.

Stable Risk. Another common type of risk of which there are probably eighty thousand in the United States, is the stable risk. It may be rated as a good many are, something after the following manner:

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	Contents	Building
Basis rate	$1.00	$0.50
Frame	.25	.25
Area (over 5,000 square feet)	.10	.10
Fire pails	.10	.00
Unsafe lights	.10	.10
Untidy condition	.10	.10
	$1.65	$1.05

In this case the removable charges are those for fire pails, unsafe lights, and untidy condition. The base rate, charge for frame and area being fixed charges.

In connection with such properties as stables and to a degree with all properties involving animal life it must be borne in mind that the animals are affected by the smoke the same as a human. Their lungs are not built to inhale smoke any more than the human, while in the case of horses fire possesses a peculiar fascination in that they seem to run directly toward the fire instead of away from it. In order to lead them from a burning building it is frequently necessary to throw something over their heads and blind them. The danger from fire to horses increases naturally with the increased difficulty in getting them out of the building. Hence, if located above the grade floor an additional charge is imposed, this charge increasing according to the number of stories that the horses are kept above grade. Thus, on the second floor it may be ten cents, third floor twenty-five cents, fourth floor forty cents, fifth floor fifty-five cents, and sixth floor seventy cents.

If the stable be of fireproof construction it is possible, and has been done, to construct an outside runway which permits the horses to be led direct from any floor to this outside runway and then brought down to the ground. A better way, of course, is to sprinkle the stable and catch the fire in the beginning.

Furniture Warehouse. A furniture storage warehouse whose rating will normally proceed on the line indicated in the case of the stable will furnish a few more points in the progress of rating. It will be assumed that the building is of ordinary construction.

	Contents	Building
Base rate	$1.50	$1.00
Height (six stories)	.05	.05
Sky lights	.05	.03
Floor openings	.10	.06
Work (repairing and painting) (2 hands)	.10	.10
Stable	.10	.10
	$1.90	$1.34

The removable charges in this case would be the sky lights and floor openings, fifteen cents on the contents rate and nine cents on the building rate. The same amount is not charged the building for these deficiencies as the contents because they are deemed more dangerous to the contents than to the building. The next item that may be removable is the repairing and painting, which may be found to be not absolutely necessary in this building, but can be done somewhere else, or it may not be possible to conduct the business as desired, and have this done at some other location, then the charge will have to remain. The charge for the stable is made because a stable is an additional hazard to the property. The hay and straw together with the lights which are usually used about a stable furnish additional opportunity for a fire starting, hence, this additional charge.

Old-Time Manufacturing Schedule. The old-time manufacturing schedule would represent the next step in passing to a higher example of rating. For an illustration a hand-power piano factory in an ordinary building will be taken.

Base rate	$1.75
Sky lights	.05
Communications (two sides approved)	.10
Area (18,850 square feet with two division walls)	.24
Fire pails (none)	.10
Watchman service (none)	.05
Benzine (ten gallons)	.25
Dry room (non-standard)	.10
Total	$2.64

This rate presents several points where improvements may be made as in the sky lights, fire pails, watchman service, reduction in the amount of benzine used, and the making of the dry-room standard.

In regard to the charge for area it should be noted that the schedule permits without a charge five thousand square feet. For each additional five thousand square feet or fractional part thereof a charge of twenty cents is made, hence, there would be an additional charge of thirty cents, but this is subject to a reduction of twenty per cent because two division walls are in the risk, thus affording some opportunity of confining a fire to a smaller area, so the actual charge for area is twenty-four cents. Enough examples have been given to furnish an idea of how various schedules operate. The examples given are not the most difficult neither are they the simplest. The effort has been to make them progressive, that the student might observe how the problem grows more complex as business conducted increases in hazard.

Miscellaneous Schedules. The interest in connection with the subject of rating is almost entirely wrapped up with the specifically rated risks. These are the risks where the values rise into millions, and which differ so in their areas, construction, hazards, the business conducted and multiplicity of tenants, as to make it absolutely necessary to handle each property specifically in order to secure just results. A list of the schedules, as they are termed, which are used will serve two purposes. It will show the variety, and at the same time, show the class into which the properties fall for insurance purposes. The list given is perhaps typical of all rating organizations, although it may be somewhat larger than many of them have. There is a schedule for churches, piers, breweries, electric-light and power stations, repair shops of electric-light and power stations, car sheds or barns of electric-light and power stations, fireproof electric-light and power stations, sugar refineries, chemical plants, hotels (fireproof and non-fireproof), ferry houses, theaters, and like places of amusement. It will be noticed that this list covers properties which are usually constructed for a specific purpose as shown by their names, church, theater, etc. For that reason, the schedule takes the name of the property. These properties are not, as a rule, readily adaptable to any uses other than those for which they are originally designed. The investments are generally continuous during their existence for the purposes for which they were erected. Hence, the underlying reason for making schedules to determine the rate of insurance for such classes is based on the idea that the schedule should take into consideration the normal manner of constructing such properties, the use to which they are put, and base its rate and charge accordingly. The treatment of a church must be quite different from the treatment of an ordinary factory. The same is true of a ferry house or a hotel.

Minor schedules, based, not on special buildings, but yet adapted to the specific occupancy, are those for furnished rooms and lodging houses, the latter meaning the cheaper sort of lodging house which is perhaps only found in larger cities. However, after all, these special classes have been taken care of, it is evident that there remains a large number of buildings, some thousands which are between the minimum-rated class and the specific classes referred to. To take care of these, schedules have been provided which are capable of a variety of uses and this variety makes them adaptable for the purpose. There is a general manufacturing schedule, one for apartment houses or stores and dwellings, which are too large to be handled safely by the minimum rate, and usually a general schedule being simple in its make-up, which is adaptable to risks too indefinite in their character to fall either into the mercantile or manufacturing class. The main general schedules will be the *heavy manufacturing schedule;* and the *mercantile schedule,* the latter being designed to take care of the great body of mercantile and light manufacturing risks. The number of properties to which these schedules apply can best be shown by taking a live city which gives actual conditions. In New York City there are probably 350,000 buildings. Of this number one building in seven is subject to a specific rating. This leaves 300,000 buildings which fall into the minimum rating class. Of this number 100,000 are apartment houses, or according to the legal New York definition, tenements, that is, they have provision for housekeeping for three or more independent families. This leaves nearly 200,000 buildings which are occupied as private dwellings or by one or two families. In the group of 50,000 buildings which are subject to specific rating the actual numbers of the different classes are about as follows: There are 200 hotels; 100 theaters; 50 ferry houses; 10 chemical plants; the same number of sugar refineries; 100 electric-light and power stations, car houses, etc.; 1,500 places of worship; 400 piers, and 100 breweries. It will be noticed then, that even in number the specific schedules cover only a few properties leaving the great bulk to be taken care of by the two or three general schedules which are compiled for that purpose.

The importance of the sprinkler and the gradual evolution which has taken place in its installation and also in the increased allowance which is made for it has led, with experience, to the devising of a special schedule to measure its value.

ILLUSTRATIVE EXAMPLES

A few examples of the special schedules will be interesting and possibly helpful.

1. *Church Schedule.*

Name of Church..

Street Location.. *Survey No*................ *Map No*..................

	Basis	Add	Deduct	Add	Deduct	Building	Contents other than Organ	Organ
Brick or stone building	.25							
Frame building	.60							
Area above 5,000 square feet, each 1,000 (Max. .10)		.01						
.10 .05								
Tower—wood, slate, or metal, on wood		.05						
*Stove or furnace heat (See below)								
Steam heat, except one stove in vestry or janitor's room		.02						
Height less than 35 feet			.05					
Area less than 2,000 square feet			.05					
No concealed spaces in finish			.05					
Metallic lath and plaster or fire block finish			.02					
Parish or school houses communicating with church on one floor only			.05					
Brick or stone buildings, for contents other than organ, add		.10						
For organ, add		.35						
Frame buildings—contents other than organ, same as building								
Organ—add		.40						
Exposure, according to same								
Final Rate								

*STOVE OR FURNACE HEAT.

Brick Building		Frame Building	
Building	.05	Building and contents	.15
Contents			
Organ		Organ	.25

Parish or School House—Building,

Contents,

2. *Pier Schedule.* This deals with a type of hazard that represents but a few points owing to the simple construction of the property.

Ordinary frame construction with corrugated iron sides and metal or gravel roof, Standard rate..

Pier of..

No.............., ...R..................................

ADD				
All Wood	25c. to 50c.			
Two Stories	10c. to 15c.			
Boiler on Pier	15c. to 25c.			
Age and General Condition	15c. to 25c.			
Fiber	15c. to 25c.			
Unprotected Columns	5c. to 10c.			
Watchman	5c. to 10c.			
DEDUCT				
Iron Frame and Construction	10c. to 35c.			
Pump, Hydrants, Stand Pipes Hose-ready, Buckets every 50 feet Special call	10c. to 35c.			

3. *Manufacturing Schedule.* This manufacturing schedule is now in use and has been for over twenty years, if not longer.

	Minimum Hazard Rate	
	Add for deficiencies:	
(1)	Walls, frame or not standard	.50
	Part frame	.25
(2)	Roof not standard	.05
	Mansard according to exposure	.05
	Skylights	.05
(3)	Cornice not standard	.05
(4)	Height, each story above 5 or 60 feet	.05
(5)	Floors not standard	.05
	Ceilings	.05
(6)	Floor Openings, unless closed in accordance with standard	.10
(7)	Shutters, exposed sides, not standard	
(8)	Communications	.05
(9)	Heating, other than approved steam heat	.05
(10)	Lighting other than approved gas or electric light	.05
(11)	Ground Area:	
	Each additional 5,000 square feet	.10
(12)	Fire Appliances, no buckets or not in proper order	.10
(13)	Watchman, no watchman, or watchman without approved clock	.05
	CHARGE DISCRETIONARY	
(14)	Fire Heat	.10
(15)	Benzine or similar product	.10 to .25
(16)	Wood Working, unless a wood worker	.25
	Hand	.10

(17)	For each additional occupant	
(18)	For Exposure, bad construction or condition, charge according to hazard	
(19)	Waste, not properly cared for	.05
	Hazard deficiencies:	
(20)	Oiling, Varnishing, Painting	.05 and up
(21)	Storage, Paints, Oil, Varnish, Turpentine, Alcohol	.10 and up
(22)	Drying, except in fireproof room	.10 and up
(23)	Storage or use, Hay or Straw	.05 and up
(24)		
(25)		

The final rate would be the contents rate, the building taking a percentage of the contents rate.

4. *Theater Schedule.* This schedule illustrates a somewhat different principle as, in addition to providing the charges which are to be made in addition to the base rate, it also furnishes opposite each item the standard for which no charge would be made.

STANDARD REQUIREMENTS

(1) Building—Brick or Stone.

(2) "A"—Walls—As required by building laws and ordinances. Proscenium wall between entire stage section (dressing rooms, scene dock, property rooms, repair shops, and stage) and auditorium to start from foundation below stage and extend 5 feet in the clear above the roof line and above any skylight and coped. Also charge for other structural defects, except unprotected iron work, under this item.

"B"—The stage opening as arranged for curtain shall have an approved curtain of asbestos fiber, woven into cloth, and curtain shall be used as drop curtain at all performances. All other openings to be protected with standard fire doors on each side of wall except opening to musicians' pit which requires but one door.

(3) Roof—To be covered with slate or metal or approved composition; stage roof to have approved skylights arranged to open automatically, and rope brought down to stage.

(4) Cornice—To be of brick or stone or all metal; no exposed woodwork at cornice.

(5) Heating—To be by approved steam appliance; the boiler to be in separate building, or in fireproof room securely cut off by standard automatic fire door on one side of wall. No charge for stoves in premises of mercantile tenants.

(6) Lighting—To be approved electric lights; incandescent lights only on stage with emergency gas fixtures in auditorium. Bunch lights, electric, not required to be caged.

(7) Fire Protection—At each side of the proscenium opening on the stage, one 3-inch standpipe, with one hose connection on the stage and on each side of the flies; gate valves to be used at each hydrant with 25 feet of 2½-inch standard cotton hose; and one brass hose pipe (1¼-inch opening) attached to hose. Standpipes to be connected with elevated tank on roof, unless city water pressure is sufficient. One 3-inch hose connection in lobby, with 50 feet 2½-inch hose.

(8) Warranty No. 1—Requires that the assured shall keep a forty-gallon barrel filled with water, also six buckets filled with water, one fire extinguisher, two axes and two hooks on each fly gallery, on each side of the stage, and in property room, repair shop and paint shop. In addition to warranty requirements, equipment as above must be installed under stage.

(9) Warranty No. 2—Requires that the assured shall maintain a night and Sunday watchman with watch clock, having stations on each floor of the building, and on stage and each fly gallery and in property room, repair shop and paint shop, and a Special Building Call connection with Fire Department Headquarters.
(10) Automatic Sprinklers—Full equipment over stage per requirements of Board of Fire Underwriters.
(11) Glue or colors to be heated by steam.
(12) Carpenter shop to be in separate building or securely cut off. If used only for storage of tools, no charge.
(13) Dressing Rooms—In separate brick building securely cut off.
(14) Scenery Store Room—In separate brick building securely cut off. Note—Items 12, 13, 14, and 15 may be in one building.
(15) Property room to be outside and cut off.
(16) Smoking—Not to be allowed except in play as required.
(17) Waste, Sweepings, and Rubbish—Removed daily; metal receptacle for waste and sweepings wherever required.
(18) Building to be protected from exposure where necessary; to have separate exit from auditorium and stage; to be kept clean and orderly throughout, and free from accumulations of old scenery and properties.
(19) Single Occupancy.
(20) Roof Garden should be well protected.
(21) Structural Iron Work in fireproof buildings should be protected.
(22) Work—Manufacturing of costumes should be carried on outside of building.

A deduction of $1.00 shall be made when fifty per cent or more of the use of the theater is for other than theatrical or operatic entertainments.

Basis Rate..................

CHARGES FOR DEFICIENCIES

(1) Building	
One-half frame or less	$0.50
All frame	1.00
(2) Walls	
A—Not according to building laws	.25
B—Proscenium wall not according to standard (No asbestos curtain, and openings not properly protected)	.50
(3) Roof	
Shingle	.25
Non-approved roof	.05
No skylight in stage roof, or not arranged to open automatically	.25
(4) Cornice	
Wood boxed	.05
If cornice extends without break, including both stage and auditorium	.05
(5) Heating	
Heater safely arranged	.10
Stoves burning coal safely arranged	.10
Steam heating not approved	.10 and up
(6) Lighting	
Petroleum	.50
Gas	.15
Bunch and strip lights not caged	.25
Rubber tubing	.10
Swinging or defective gas brackets	.10
Gas lights in the dressing room not caged	.10
(7) Fire Protection	
No standpipes, hydrants and hose with approved water supply	.15

(8) Warranty No. 1	.10
(9) Warranty No. 2	.10
(10) Automatic Sprinklers	
None	.15
(11) Glue or Colors	
Heated by other than steam	.10
(12) Carpenter Shop and Electric Repair Shop	
In building or in building not securely cut off	.10
(13) Dressing Rooms	
A—Underneath stage	.15
B—Not underneath stage nor in separate building	.10
(14) Scenery	
Stored on stage	.10
Stored in attic over or in basement underneath auditorium or under stage	.15
(15) Property Room	
Under stage	.15
Outside but not cut off	.10
(16) Smoking	
Other than by actors as required during the play	.10
(17) Waste, Sweepings, and Rubbish	
Not removed daily	.10
No metal receptacles for waste and sweepings	.10
(18) Add for exposure according to rule, and condition according to hazard.	
(19) For one additional occupant	.05
For two or more additional occupants	.10
(20) Roof Garden if any	.25 to .50
(21) Unprotected Structural Iron Work, not more than	.50
(22) Work—If costumes made in building, or other manufacturing work	.25 to 1.00

NOTES

In rating fireproof theaters, charge 50 per cent of above deficiencies, and add 75 cents to building rate for contents. If non-fireproof theaters, add 50 cents to building rate for contents.

Reductions: In buildings of ordinary construction, and having wire lath-and-plaster finish throughout, 10 per cent of basis rate. In buildings of ordinary construction with wire lath-and-plaster finish throughout, and stage built fireproof, 20 per cent of basis rate.

Vestibule Buildings: In vestibule buildings where communications exist in basement or on first floor, rate by mercantile schedule and charge 25 per cent of theater building rate additional for exposure. If communication is above the first floor, the building shall take the same rate as the theater.

Basis Rates: Non-fireproof, $2.00; Fireproof, $1.00.

If standard steel curtain installed with automatic water curtain back of same deduct 25 cents from building and contents rate.

If approved sprinkler equipment in entire stage section having two sources of supply independent of city connection standpipe system, also connected with both sources af supply deduct 15 cents from building and contents.

Use of Base Rates. The principle involved in these base-rate schedules can probably be best shown by an actual example of the rate on a *paper box factory.*

Minimum Hazard or base rate	$1.25
(Roof, not standard) composition	.05
Height, 6 stories	.05
Heating (stoves)	.05
Total	$1.40

This is the rate on the contents, and the rate on the building is a percentage on this rate, usually 70 per cent. In this example it will be noted that no charges are made, with the exception of the base rate and three other items. Every other charge provided by the schedule is not made, since the conditions do not call for it.

In the use of this type of schedule there may be different base rates, but there is slight variation in the other charges. The base rate is usually a fixed amount. In the case, however, of one or two businesses it is a small rate in itself. Thus, in the case of *printers*, the base rate is made up something as follows:

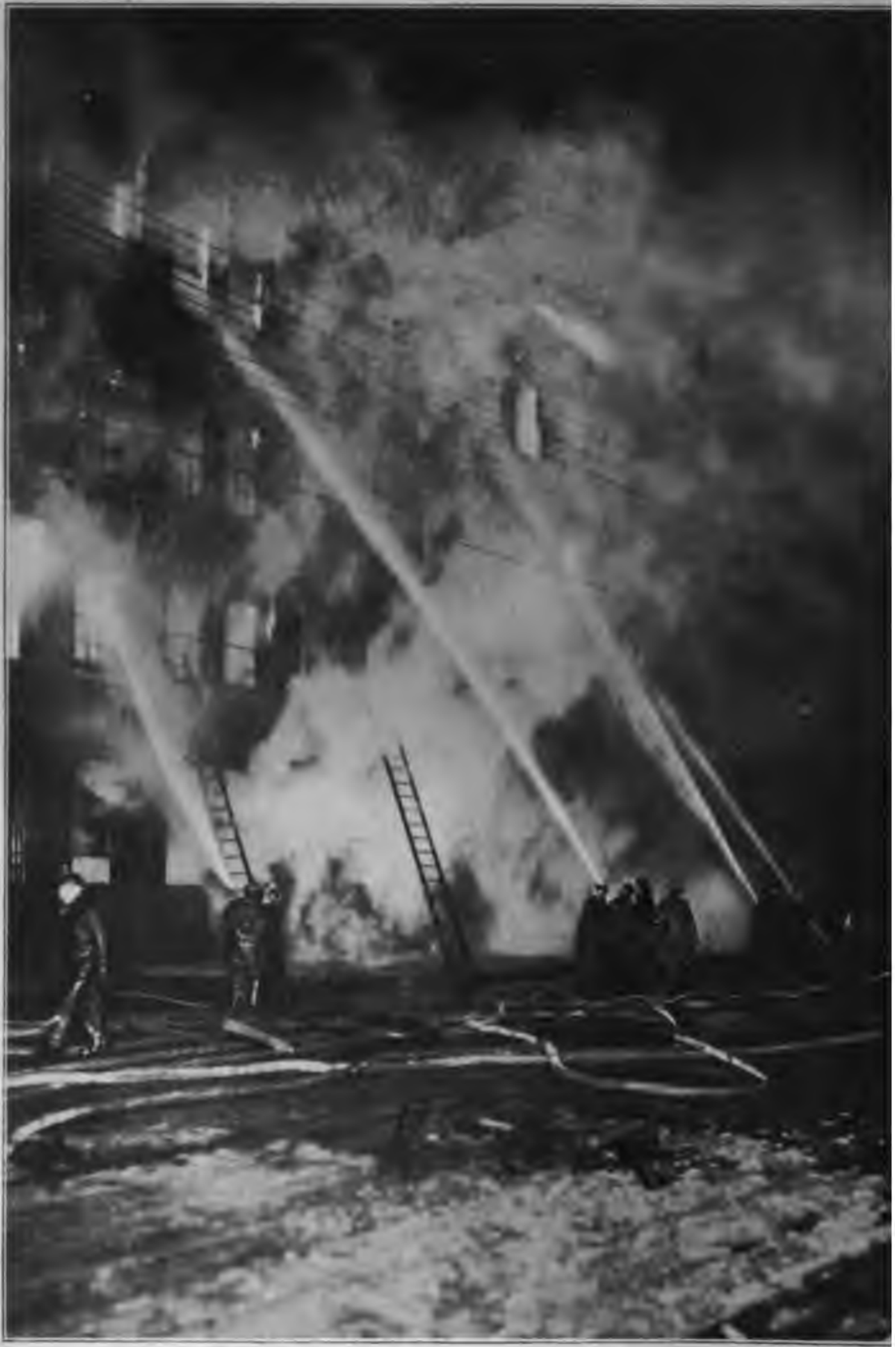
Initial base rate........	$.80

This is for an ordinary job printer, foot power with not exceeding three job presses. Should he, however, use some form of mechanical power, an additional charge of fifteen cents is made. If the number of presses exceed three an additional charge is made for the increased number of presses, generally five cents for each three job presses, or one cylinder in addition to the three job presses or one cylinder allowed by the base rate. Finally, if the presses are above the first floor, thus rendering them more dangerous to themselves or to the property in the event of a fire, since the heavy presses tend to weaken the building and to break down the floor, an additional charge is made, generally of one cent for each floor above the first on which the press is located. A typical base rate for a printer, therefore, may be made up as follows:

Initial charge....................................	$0.80
Power.	.15
5 cylinder presses, in all, additional charges.........	.20
4th floor height charge...........................	.15
Total base rate.................	$1.30

The charge of twenty cents for extra presses is five cents for each cylinder press in addition to each one allowed in the base rate. The charge for height above grade is one cent for each story that each press is above the grade. Each press in this case is three stories above grade. Hence, for the five presses we have a charge of fifteen cents. Therefore, in rating a printer it is necessary first to determine the base rate that applies and when that is done to then examine the property, to see if any of the other charges should be made. A schedule is simply a measuring rod, its purpose being, in brief, to measure the risk. In fireproof properties, as distinguished from non-fireproof, certain charges are not of so much moment because of construction of the building, while in a non-fireproof every hazard practically affects the whole property since a fire at any one point is apt to spread throughout the building. That is the reason why in a non-fireproof risk of any serious hazard that one rate generally will apply throughout.

All that has been presented has been to pave the way for the consideration of the most important schedules, the Universal and the Analytic.



A NIGHT FIRE IN BOSTON, MASSACHUSETTS
Showing Use of High Pressure Streams

FIRE INSURANCE RATING

PART II

UNIVERSAL MERCANTILE SCHEDULE

It has been an ideal towards which underwriters have steadily worked to produce a schedule that should be capable of rating all kinds of risks and thus abolish the variety of schedules which it has been pointed out are in use. There is a general agreement among all interested in the business that a schedule capable of universal application is one of the most desirable things in the business today. But it is still some time in the future before that point will be reached or before a schedule will be produced capable of answering the purpose. Two attempts to accomplish this have been made, both partially successful. The first is known as the Universal Mercantile Schedule. It probably originated with F. C. Moore, formerly president of the Continental Insurance Company, but various committees were appointed who co-operated in the matter. The schedule was tested out in six preliminary editions and in the year 1893, it was published practically as it is today. The schedule should be allowed to speak for itself at least in the beginning and it lays claim to the following seven fundamental principles.

Fundamental Principles. (1) A schedule should recognize a key rate as a starting point, viz: The rate of a building of standard construction in a standard environment, *i. e.*, in a city presenting the most favorable conditions for the prevention, discovery, extinction, and confinement of fires to single buildings; and that the difference between the starting point, or base rate, of one city as compared with another should be explainable by charges for variation from standard. Unless differences between two cities as to the same character of structure are explainable, jealousies and antagonisms will result in developing adverse legislation.

(2) Inasmuch as all the risks of a city can not have the maxi-

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mum benefit of the fire department, especially where street water mains are of inadequate sizes, it is clear that all risks in the city should not be rated alike, even though identical in construction and occupancy, but that they should differ according to the sizes of street mains, proximity to hydrants, fire engine houses, etc.

(3) Certain features of construction, like self-releasing floor beam, for instance, which improves a building, are of no benefit to the stock. The stock, therefore, should not receive credit for them in the rate. A system of rating which adds some fixed sum to the final building to get the stock rate must of necessity result in an inadequate stock rate.

(4) Fire extinguishing appliances, especially for throwing water, should not receive credit in computing the rates of stocks to the same extent as in computing the rates of buildings, because water throwing damages stocks to a greater extent than buildings.

(5) Exposure in the case of buildings should be treated differently from stocks. A building may be so constructed as to be a complete protection to its stock, but require a charge in its own rate for possible damage to its exterior paint, etc., etc.

(6) The rate of a stock should approach that of the building containing it in proportion as the latter is of poor construction, liable to be totally destroyed, and in proportion as it is deficient in fire extinguishing appliances; whereas, there should be a great difference between the rate of a building and its stock if the building is of standard construction and its fire extinguishing appliances are of the best. And this difference in rate should never be determined as a matter of judgment but by some automatic process which will adjust the difference in rate to the conditions. Unlike other schedules, the Universal has provided for this vitally important feature.

(7) The fire record of a city should be taken into account in computing rates, both at the beginning and ending of the term for which the rate is computed. The Universal Schedule recognizes this.

The Universal Mercantile Schedule, with the exception possibly of the city of Rochester, where it was first applied almost in its original form, has not been used exactly as printed in any city or town. It should not be inferred from this that radical changes have been made in the schedule itself. The difficulty attending a Universal Schedule is that conditions are not the same in any two cities, probably, in the world, and when there is added to the larger cities the variety of conditions found in the country districts, it is not difficult to realize that a schedule to meet all conditions without any modification would represent the work perhaps not of men but of beings of some higher power. When applied to different parts of the country the schedule has then been adapted, so to speak, but its principles, we believe, have been fairly followed. The schedule represents probably the first attempt to approach, in a scientific spirit at least, the question of rating properties for fire insurance purposes. Certain charges which appear in all schedules, almost from the beginning, appear in the Mercantile. It is possibly the final expression, in the process of evolution, towards a schedule which, although built somewhat on the old lines, still involved many new principles which, if recognized before, had not been used.

No comment on any of the various items which enter into any schedule has been made up to this point. This is due to the fact that it was desired to reserve all comment and elucidation of the various items of rating schedules until the universal was reached. This is the wisest course to pursue because its use in so many cities makes it a more or less familiar document and because it contains within itself the best of the good things found in the old schedules.

In the cities of Boston, New York, Philadelphia, Chicago, and others the schedule has had a very complete test and had a very wide use. It was applied in the early '90's to quite a number of risks in Brooklyn, but in the year 1900, shortly after the formation of the present rating body, The New York Fire Insurance Exchange, it was formally adopted for that territory. The varying conditions which are found in the city of New York, the large number of buildings to which it has been applied, makes the schedule as used in that territory the best one on which to base comments.

The schedule properly falls into these divisions:

A. The key rate.
B. The building deficiency charges.
C. The occupancy charges.
D. The reductions for fire extinguishing appliances.
E. The exposure.
F. The coinsurance.
G. Faults of management.

In the schedules which have been illustrated thus far, it will be noted that the base rate was generally a large amount. To take the manufacturing schedule as an illustration, the base rate for a paper box factory was $1.25. It was never expressed but this base rate undoubtedly represented the rate at which, in the judgment of the underwriters, a paper box factory could be written, provided that none of the conditions which made necessary an additional charge, existed in the risk. In an ideal risk, in other words, under the old system, the rate would have been the base rate and never more, and as ideal risks do not exist, but real live risks, departures from the ideal were measured by the deficiency charges on the schedule. These deficiency charges only amounted to ten or fifteen items and represented the points which it was necessary to consider in rating a property under that system. On the Universal Mercantile Schedule non-fireproof, a possible 125 points may be considered in rating a property. The difference between the number of points between the two systems illustrates the refining process which is provided for in the Universal.

Making a Key Rate. Turning now to the details, the key rate is the first thing to be considered. The key rate embraces those factors which affect the problem of fire insurance and which are beyond the control of the underwriter; things, in other words, with which the underwriter will, in a certain sense, have but little to do. They represent conditions which apply to the city or town as a political unit rather than to conditions which affect the individual risk and which may be modified by improvements or changes in the individual risk.

"Standard City" Defined. The schedule assumes the standard city and defines it as follows: "A Standard City is one having gravity waterworks, with head sufficient at all hours to throw over five-story buildings. The main supply pipe to be in duplicate unless intermediate storage reservoir be provided. Water pipes and mains to be not less than six inches in diameter in dwelling section, and not less than eight inches (as a minimum) in mercantile section (they ought to be ten and twelve inches); a paid fire department, 12 men to each steamer; not less than two steam fire-engines to each square mile of compact portion, or one to each 10,000 population up to 500,000 population; hook and ladder trucks, one to every

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[illegible] AND
[illegible]

four steamers; fire-alarm telegraph; efficient police; paved, macadamized, or other hard streets, the majority of which—say 60 per cent—are seventy feet or more in width; a good building law, well enforced; no outlying exposures, such as lumber districts, etc., to cause sweeping fires; no unjust municipal and State taxation, and a previous five-year fire record of not exceeding $5 annual fire loss to each $1 of insurance."

Standard Building Defined. The schedule then assumes and defines a standard building: "A Standard Building is one having walls of brick or stone (brick preferred), not less than twelve inches thick at top story (16 inches if stone), extending through and 36 inches above roof in parapet and coped, and increasing 4 inches in thickness for each story below to the ground—the increased thickness of each story to be utilized for beam ledges. Ground floor area not over 2,500 square feet (say, 25×100); height not over four stories, or 50 feet; floors of 2-inch plank (3 inches better) covered by $\frac{7}{8}$- or 1-inch flooring, crossing diagonally, with waterproof paper or approved fire resisting material between (if tin or sheet-iron between, see deductions); wood beams, girders, and wood story posts or pillars 12 inches thick, or protected iron columns; elevators, stairways, etc., cut off by brick walls or by plaster on metallic studs and lathing, communications at each floor protected with approved tin-covered doors and fireproof sills; windows and doors on exposed sides protected by approved tin-covered doors and shutters; walls of flues not less than eight inches in thickness, to be lined with fire-brick, well-burned clay or cast iron, and throat capacity not less than 96 square inches if steam-boilers are used; all floor timbers to be trimmed at least 4 inches from outside of flue; heated by steam; lighted by gas; cornices of incombustible material; roof of metal or tile; if partitions are hollow or walls are furred off there must be fire-stops at each floor."

The basis rate of a Standard Building in a Standard City is taken at 25 cents.

Deficiencies and Credits. Having assumed this standard it then furnishes a list of deficiencies and credits which will enable the key rate to be established for any city or town and in this list the following points are taken into consideration:

(1) The non-fire department towns,

(2) Waterworks, the consideration of which is divided into the following heads:
  (a) Not gravity, but direct pressure,
  (b) Pumps not in duplicate
  (c) Direct pressure. Pumps operated by steam power. Pumping machinery duplicate,
  (d) Same as (c), but pumps not in duplicate,
  (e) Direct pressure, but neither standpipe nor reservoir with a 10 hours' supply,
  (f) Pumping station endangered so as likely to be put out of use,
  (g) If the supply mains not duplicate,
  (h) Pipes in mercantile section less than 8 inches cr hydrants less than 6-inch barrels,
  (i) Water supply only from wells or cisterns or natural streams,
(3) No steam fire engines or only one,
(4) Hose,
(5) Fire alarm telegraph,
(6) Police organization,
(7) Fire department organization, none,
(8) (9) (10) If fire department less than standard,
(11) Fire department but not free from political control,
(12) Volunteer fire department,
(13) No fire marshal,
(14) Unpaved streets, exceeding 10%, impassible during bad weather,
(15) If 40% of streets in mercantile section less than 70 feet wide,
(16) No building law, or not well enforced,
(17) Trolley wires,
(18) Conflagration hazard,
(19) Natural gas or oil or fuel,
(20) High winds,
(21) Previous fire records,
(22) Exceptional features of a city. Exceptional bad features of a city, as in a southern city where the water main bringing the water supply crossed a wood bridge, the construction of the bridge meant no water for the city.

It is evident from the above that every point mentioned is beyond the control of the underwriter or the individual property owner. They may help or assist in raising the city standard in any one or all of these things, but cannot of their own will cause them to be supplied. The key rate makes certain provision for some things which may be in excess of the standard: (1) Chemical engines on wheels; (2) Auxiliary steamers where the city has a gravity waterworks system; and (3) A hook and ladder to serve four steamers.

Choice of Key Rate. While one key rate might normally be computed for the city, it is not infrequently the case that in a great many respects a large city may have in some sections certain facilities far beyond the standard and in others be only normal or even below the standard.

From what has been stated, it will be evident that computation of a key rate is a matter of applying a small schedule to the city or district chosen. There must, of course, be a full report made on the various features which enter into the key rate and these features will then be measured by the standard set up in the key rate. In the average large American city the key rate ought, under modern conditions, not to exceed twenty cents. It very seldom need run above twenty-five cents and it shows rather a bad condition if it does so.

The value of a key rate, as made up by a schedule, is that it serves to emphasize the weak points in the city concerning fire prevention. It also emphasizes the strong points. The key rate once chosen, then the individual schedule comes into use.

SCHEDULE FOR NON-FIREPROOF BUILDING

It is now a question of applying the schedule to the individual risk. One which is in actual use will serve as a text for the non-fireproof building.

Map............................ Survey No..............................
Location ....

FULL SURVEY

....

OCCUPANCY-IMPROVEMENTS

....
....

DETAILS OF FLOOR OPENINGS

....
....

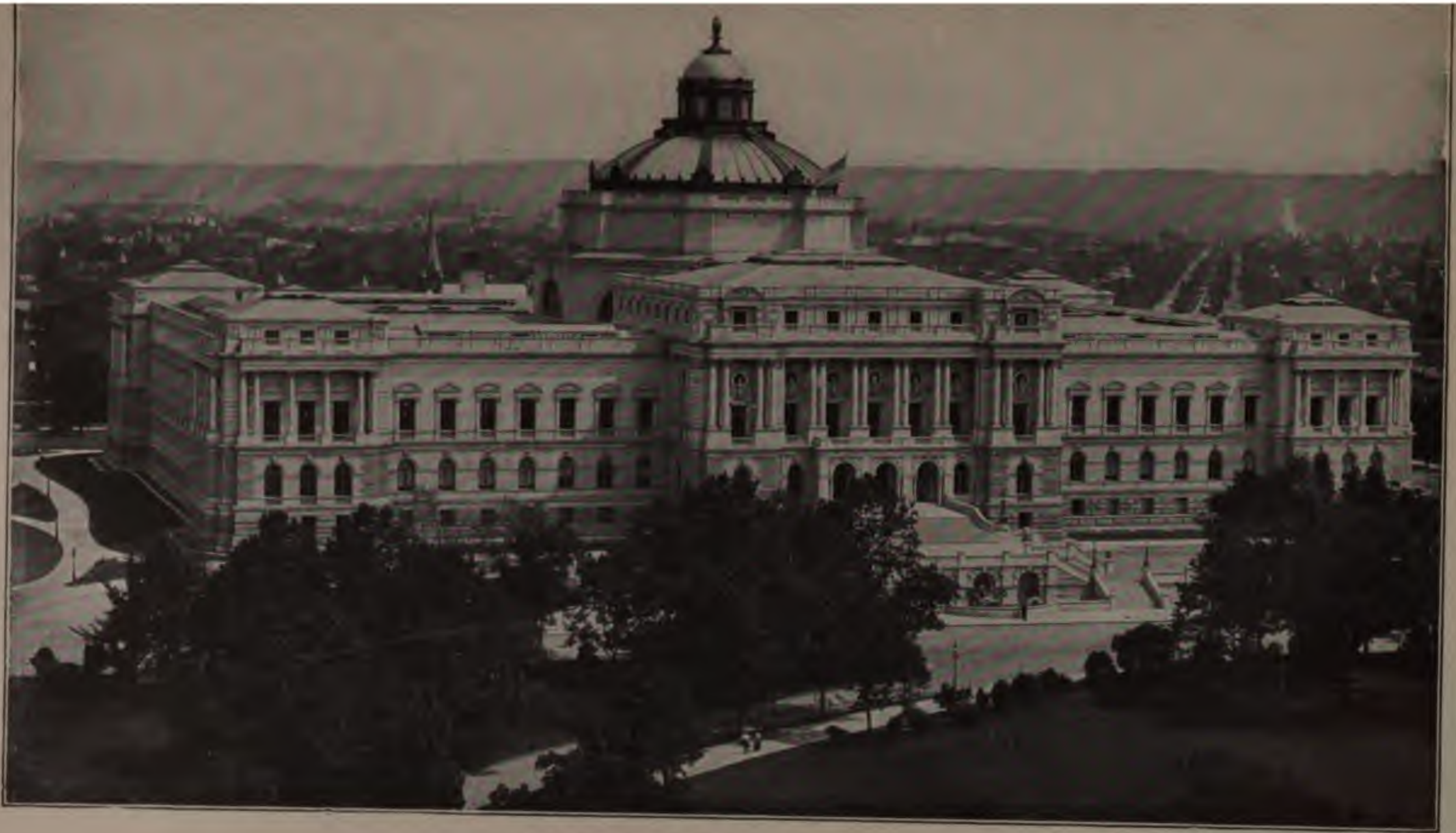
STANDARD BUILDING is one having walls of brick or stone (brick preferred), not less than twelve inches thick at top story (16 inches if stone), extending through and 24 inches above roof in parapet and coped, and increasing 4 inches in thickness for each story below to the ground, the increased thickness of each story to be utilized for beam ledges. Ground floor area not over 2,500 square feet; height not over four stories, or 50 feet; floors of 2-inch plank covered by ¾- or 1-inch flooring, crossing diagonally, with waterproof paper or approved fire-resisting material between; wood beams, girders, and wood story posts or pillars 12 inches thick, or protected iron columns; elevators, stairways, etc., cut off by brick walls, communications at each floor protected with approved tin-covered doors and fireproof sills; windows and doors on exposed sides protected by approved tin-covered doors and shutters; walls of flues not less than 8 inches in thickness, to be lined with fire-brick, well-burned clay or cast-iron, and throat capacity not less than 96 square inches if steam boilers are used; all floor timbers to be trimmed at least 4 inches from outside of flue; heated by steam; lighted by gas; cornices of incombustible material; roof of metal or tile; if partitions are hollow or walls are furred off there must be fire stops at each floor.

WALLS.—A STANDARD INDEPENDENT WALL should be 12 inches at the top story, and increase 4 inches for each story to the bottom. This would require if three stories, 12 plus 16, plus 20, total 48, divided by 3, or an average of 16 inches; a 4-story standard wall would average 18 inches; 5-story, 20 inches; 6-story, 22 inches; 7-story, 24 inches, etc. (Stone walls must average 4 inches thicker each story).

A STANDARD PARTY WALL should average for a 3-story building 20 inches; 4-story, 22 inches; 5-story, 24 inches; 6-story, 26 inches; 7-story, 28 inches. (Stone walls must average 4 inches thicker each story.)

		No.	Amount
KEY RATE (being Key Rate 25c. less deductions)	.10		
WALLS. 38 Indep't (for party see 40) each 4 in. variation from stand.	.01		
(Buildings over 3 stories high double charge)			
39 On Buildings over 3 stories if average 12 in. or less add in addition to above not less than .04. (If 2 independent walls adjoin deduct 4 inches from average requirement.)			
Party Walls 40—Each 2 inches deficiency from standard add	.01		
41 If less than 12 inches in any part add not less than .05, if over four stories double charge			
Charge for one wall only, the most deficient.			
(Note—Walls under Building Law may be regarded as standard.)			
42 Walls not Parapet 12 inches above roof and coped each exposed side	.03		
43 Poor Bricks or poor quality mortar	.10		
44 Each Iron Front or side not backed up with brick and mortar	.03		
45 Iron Fronts backed up with brick and mortar	.01		
46 Each Iron Front in row add in addition to above	.01		
46½ Stone Front or side, each	.03		
ROOF 47—Composition	.01		
48 Slate	.02		
49 Shingle	.08		
50 Mansard with wood frame, four story or lower, one side	.07		
51 Each additional side .03. Increase charge 5 cents for each story over four			
52 Roof space, blind attic or cock loft each vertical foot .01 not over	.05		
FLOORS 53 -Double Flooring less than 3 inches thick	.02		
54 Single Flooring	.05		
55 Floor Joists less than 3 X 10 inches	.03		
CEILING OR SHEATHING 56- Wood or Strawboard ceiling or wood lath furring on walls one story .03, each additional story	.02		
57 Wood or Strawboard siding one story .05, each additional story	.03		
57a Cloth or paper ceiling or siding on wood studs, each story	.05		
59 Each 1,000 sq. ft. in excess of 2,500 sq. ft. add	.03		
Limit 6 story or under 1.00 over 6 story 1.50. Sole tenant 20% off. (Deduct 10% of area charge for each wall dividing and strengthening the risk, not exceeding 40% of area charge.			
AREA (Ground Floor .... x .... Total......sq. ft.			
HEIGHT 63 ....Stories—Fifth Story	.03		
64 For Sixth Story	.05		
65 For Seventh Story, .12, each story over seven .15, (cumulative)			
(Standard building may be Seven Stories without charge.)			
65a For Eighth Story on standard building	.12		
65b For Ninth Story on standard building	.20		
ELEVATORS 67 Cut off by lath and plaster hallway or shaft with self-closing doors or automatic traps	.03		
68 Open	.06		
69 Wood Shaft without self-closing traps	.08		
STAIRWAY 71 Cut off by lath and plaster hallway .06, with self-closing traps or doors at each floor	.03		
72 Enclosed in wood with self closing doors each floor	.05		
73 Open	.08		
(For each extra elevator or stairway add ½ of charge for each. If both elevator and stairway are charged make full charge for greater amount and half charge for smaller.)			
WELL HOLES, CHUTES, VENT, SHAFTS, AND DUMB WAITERS			
74 For each floor pierced not less than .01 (well holes each floor 05)			
SKYLIGHTS 76 Not standard each 9 sq. ft. over 9.02; not over	.15		

Amount carried forward . . . .



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		No.	Amount
Amount brought forward			
WOOD CORNICE, CUPOLAS, ETC. 79—Not less than	.02		
80 Wood awnings on one story buildings .05, on higher buildings	.01		
LIGHTING 84—Electricity, Approved	.01		
86 Kerosene. (No charge if charged for electricity)	.01		
HEATING 87—Furnace .02, if metallic cold air box	.01		
89 Stoves	.01		
(If 87 and 89 only charge for greater.)			
CHIMNEYS 97—Not built from ground but on brackets	.05		
99 Resting on attic floor beams or joists	.15		
100 Only one-half brick thick (4 inches) 12 (if stoves only)	.06		
101 Poor bricks or mortar (in addition to building charge No. 43)	.10		
WIRES 102—Overhead around bldg. to interfere with fire dept	.01		
105 Electric Trolley Wire to interfere with fire department	.02		
TENANTS 106—Each mercantile tenant in excess of one	.01		
106a Each Manufacturing tenant in excess of the highest rated one (which is charged for in No. 128) add ten per cent (10%) of first column charge			
106b MANUFACTURING RISKS.—Charge $\frac{1}{10}$ of .01 for each operative employed in excess of 10 not exceeding a total of 25 cents in risks where first column charge does not exceed 25 cents, and double this amount in wood working and other hazards where first column charge exceeds 25 cents, but not exceeding a total of 100 cents.			
AGE of Building 107—Over 20 years	.01		
FRAME REARS OR EXTENSIONS 108—Not less than	.05		
STONE PIERS, STONE COLUMNS, PILLARS, or brick piers with bond stones 109—carrying important weights, especially if supporting beams or girders in basements, cellars, etc., charge according to number and importance not less than	.03 each		
110 Unprotected iron columns cast iron .10; steel or wrought .15; unprotected steel girders (N.B.—Hollow columns filled with cement dangerous.)			
111 STEAM BOILER (except for heating) inside first floor or basement	.05		
upstairs .10, Wood shavings for fuel 1.00			
FIRST TOTAL			

DEDUCT FOR EXCEPTIONAL CONSTRUCTION:

		No.	%
119 Tin or Sheet Iron between floors	10%		
120 Waterproof paper between floors	5%		
121 Floor waterproof inclined to carry off surplus	5%		
122 Grade floor fireproof 10%. Each additional floor 5% (not exceeding 40% in all)			
123 Metallic stud and lathing or tile partitions throughout	10%		
124 Metallic lathing on wood studs, terra cotta or other fire resisting partitions	5%		
125 All story posts, beams, joists and girders 12 inches thick deduct	5%		

127 RATE ON BUILDING UNOCCUPIED.......

Occupied by Nos..

127a Add 50% of amount in first column for most hazardous occupancy.

128 RATE ON BUILDING OCCUPIED..................................

DEDUCTIONS FOR FIRE APPLIANCES, ETC., ON BUILDINGS

		No.	%	cts	Amount
158 Automatic fire alarm	10% to 10 cents				
158a " burglar alarm	1%				
159 Chemical engine on wheels	5%				
160 Iron fire escapes on accessible side with landings each floor	2%				
161 Casks of water or sand or filled pails on each floor (2 filled pails for each 1,000 square feet floor area)	5%				
NOTE—(Approved extinguishers accepted in lieu of half required number of pails).					
162 Standpipe internal, near stairs ample tank supply	2%				
164 Standpipe, appd. with external Siamese connections	1%				
165 Each side or rear accessible to fire department (no deduction for front or alley)	2%				
167 Bas. and / or sub-bas. with approved equipment of automatic sprinklers having approved external Siamese connection only	2%				
Amount carried forward					

No. % cts

Amount brought forward ....

173 If bldg. occupied throughout exclusively offices or office and dwelling 25%
174 If bldg. above grade floor occupied for office or offices and dwellings 10%
176 Watchman with watch-clock ....2½% to 2½ cents.
176a { Special Building Signal ....5% to 5 cents.
{ Without watchman and clock ......2½% to 2½ cents.
177 Roof hydrants (with approved hose and protected)..2%
178 Floor beams and girders, self-releasing 1%
186 FIRE BOAT. If risk within 800 feet of Fire Boat..5%

TOTAL DEDUCTIONS...... %&c.

129 NET RATE OF BUILDING OCCUPIED..........
130 EXPOSURE..........
130a " Conflagration District, Like Dry Goods Dist..........
131 RATE OF BUILDING Occupied and Exposed..........
131b SPRINKLERS. If according to the F. U. requirements, deduct. %
132 DEDUCT 15% FOR 80% COINSURANCE..........

ADD FOR FAULTS OF MANAGEMENT UNTIL CORRECTED

No. Amt.

136 Unprotected stovepipes through floors or partitions..50
136a Unsafe gas or other stoves..................10 to 25
137 Stovepipes through window, roof or wall, but with double metal chimney 50
138 Through windows not protected..................100
139 Entering bottom of flue vertically..................25
140 Entering flue in attic or unused room 25
141 Bottom of elevator shaft used for closet or waste....50
142 Swinging or other unsafe gas brackets or lamps unprotected 10
143 Untidiness, rubbish, ashes, etc., especially in cellar....................................10 to 25
143a Packing material not in bins......................15
144 Broken plastering, windows, cracked walls, etc. ....10 to 25
145 Empty boxes or rubbish in rear yard, alleys, window recesses, under sidewalk, grating, etc...10 to 25
146 Open lights in show windows....................25
146a Unsafe gas engine 25
147 Sawdust on floors, sawdust spittoons..............10
148 Benzine, according to quantity................10 up
149 Ash or waste cans approved, if none................10
149a Oily floors under machines, lack of drip-pans.......10
149b Steampipes in contact with wood................01
153 Elevator or other shaft communicating with roof space ....10 to 25
154 Electric lighting system and installation not in compliance with city ordinance and Board rules ....
Arc lights unprotected by tight globes or metal screens....................................25
154a Crowded Mdse. without proper aisles opposite or too near windows, overloading, not less than....25
Sign on roof to interfere with Fire Department......10
Communications until approved by N. Y. Board......
Unsafe Electrical Apparatus ....
Unsafe Heating Apparatus.......................

FINAL RATE ON BUILDING..........

Floor.....
Class.....
Charge...

Floor....
Class.....
Charge...

Rate of building occupied, No. 128, above............ .cts.
Deduct a sum equal to 10% of deficiencies of building, *i. e.*, 10% of excess of item No. 127 over 10 cents (or .20 or .25) as follows:
Rate 127...........cents, minus 10 cents (or .20 or .25) equals..........cents; 10% of which (.. ....cents), deducted from No. 128 leaves.
....
Key Rate.

Amount carried forward ....

Floor.....	Floor.....
Class.....	Class.....
Charge...	Charge...

Amount brought forward ....

This will be the KEY OR BASIS RATE FOR ALL STOCKS IN BUILDING

Add 75% of amount named for stock to be rated (No..........) in second column of Occupancy Table........................

Add, if entire stock is above or below grade floor, each floor, 5 cents..

If distributed over two or more floors, add the charges for all and divide by the number of floors covered to get the average. For example, for third floor 10 cts., fourth 15 cts., and fifth 20 cts., total 45 cts., divided by 3 equals 15 cts. If stock extends only over the three floors—grade, basement and second floor, no charge or deduction.

TOTAL..

DEDUCTIONS FOR FIRE APPLIANCES, ETC., ON STOCK

No.	%	cts.

193 Automatic fire alarm....10% to 10 cents
193a Automatic burglar alarm.............1%
194 Chemical engines on wheels...........5%
195 Iron fire-escapes outside of building on accessible side with landing at each floor..........................2%
196 Casks of water or sand or filled pails (two filled pails to each 1,000 sq. feet of floor area)................5%
NOTE—(Approved extinguishers accepted in lieu of half required number of pails).
197 Standpipe, internal, near stairs with tank supply.......................2%
198 Standpipe, with external Siamese connection for use of fire department....1%
199 Each side or rear accessible to fire department (no deduction for front or alley).........................3%
201 Bas. and/or sub-bas. with approved equipment of automatic sprinklers having approved external Siamese connection.......................2%
207 If building occupied above grade floor for offices.......................5%
208 If for office and dwelling.............10%
210 Watchman with watch-clock.......... ....2½% to 2½ cents
210a { Special Building Signal.....5% to 5 cents Without watchman and clock....... ....2½% to 2½ cents
211 Roof hydrants (with approved hose and protected)........................1%
213 Merchandise covered by tarpaulins each night........................5%
214 Merchandise in tin covered cases......5%
215 Skids. If merchandise in bales or unopened cases or similar original and unbroken packages is kept on skids or platforms 6 inches high, deduct......2%
216 Grade floor stock; if stock exclusively on grade floor, deduct 5%; if stock extends only over one additional floor, basement or second, skidded...3%
221 FIREBOAT. If risk within 800 feet of Fire Boat.......................5%

TOTAL.................... % & c.

134 RESULT.—(See note.) Rate on stock in unexposed building..

Note to No. 134.—The rate on stock at No. 134 shall exceed the rate on building at No. 129 by a sum equal to 20% of th second column charge in Occupancy Table, if not, increase to that amount.

134a EXPOSURE..
134b Conflagration District, outlying exposures, etc..........
TOTAL..

134c **SPRINKLERS.** If according to requirements of Fire Underwriters deduct .... %				
135 **DEDUCT 7½% FOR 80% COINSURANCE**				
ADD FOR FAULTS OF MANAGEMENT, same as building				
FINAL RATE ON STOCK				

EXPOSURE

Calculate the exposure, as per tables, for given distance or condition for each side and enter in its column, add or subtract from charge as follows, carrying the net result by successive processes down the column to the bottom.

	Front	Right	Rear	Left
Height	.....	.....	.....	.....
Rate	.....	.....	.....	.....
Distance	.....	.....	.....	.....
Length of Side	.....	.....	.....	.....

RATE OF EXPOSURE LESS THAN 1 PER CENT prorate charge.

BUILDINGS SEPARATED—with openings.
(N. B.—Wood Cornice or Wood Mansard same as openings.)

BLANK WALL OF RISK towards exposure deduct ⅘ of charge. (*No deduction if wood cornice or mansard.*)
" " OF EXPOSURE towards risk, deduct ½.
" " TO BOTH deduct 90 per cent.

OPENINGS NOT OPPOSITE each other deduct 30 per cent.
" ON GRADE OR FIRST FLOOR ONLY, deduct 25 per cent.

SHINGLE ROOF TO RISK increase charges 50 per cent but not exceeding a sum which would make risk equal rate with exposure.

IF BUILDINGS ADJOINING—Charge as per tables E and F.

WALLS NOT THROUGH ROOF.—If division wall between two adjoining risks does not extend through roof, cutting off roof timbers, charge same as per tables E and F for communications above first floor with single fire door.

LENGTH OF EXPOSED SIDE OF RISK.—Less than 75 running feet, 1 per cent less for each foot. *No deduction if adjoining with communication.*
OF EXPOSURE.—Less than 75 feet, ½ per cent less for each foot.
(N. B.—No deduction under these items, however, if the exposure building contains Oils or other "grease risks," Wholesale Drugs, stocks of Furniture, Agricultural Implements, Carriage or Wagon materials or other wood risks—hazards of intense combustibility.)

HEIGHT OF EXPOSURE.—If less than 5 stories deduct 10 per cent for each story less than 5. If over 5 stories add 25 per cent for each story over 5.

FALLING WALL HAZARD.—Add not less than 2 per cent of the rate of the exposing risk.

GLASS FRONT OR SIDE OF RISK.—Increase charge 10 per cent if first story, 20 per cent for second, and 10 per cent for each additional story.
" OF EXPOSURE.—Increase charge 20 per cent for each glass story above first or grade floor.

FIRE SHUTTERS.—To window openings of risk deduct ⅔.
" " To window openings of exposure deduct ⅓.
" " TO BOTH risk and exposure deduct 45 per cent.
(SHUTTERS must be standard.)

LARGE AREA OF EXPOSURE exceeding 10,000 square feet and height exceeding intervening distance increase charge 20 per cent and add a further 2 per cent for each 1,000 in excess of 10,000.

FRAME EXPOSURE increase charge 50 per cent but not exceeding a sum which shall make rate of risk equal to 80 per cent of exposure.

Amount carried forward ....

	Front	Right	Rear	Left
Amount brought forward				
IF BOTH RISK AND EXPOSURE RATES ARE BELOW 1 PER CENT.—Take such percentage of final result as the rate of risk bears to 1 per cent, *e.g.*, if 65 cents, 65 per cent; if 45 cents, 45 per cent, etc.				
Total Exposure Charge for all sides.				
HEIGHT OF RISK.—If under five stories high, deduct 15 per cent of total charges for each story less than five. If over five stories high add 15 per cent for each story over five.				
STOCKS.—If building separated has blank wall towards exposure, charge 30 per cent less on stock than on building. **Stocks in Standard buildings one-half the charge for exposure to building no matter on what floor located.**				

DISCUSSION OF BUILDING CHARGES AND DEDUCTIONS

Every point in the schedule represents a fire. Some points represent perhaps thousands of fires. They represent them in the sense that they present for charges the weaknesses which, in the case of fires, have increased the loss. It will be necessary to comment on some of the points with more minuteness than the mere repeating of them in a schedule permits of being done.

Walls. The wall of the building should accomplish two things, namely: It should hold the fire which has started within the building and if one starts outside, it should prevent it from getting into the building. A poor wall is a fundamental weakness in a building. In regard to iron fronts and stone fronts, it is interesting to note that the iron front was considered quite a discovery when it was first invented. There were some who, in their enthusiasm, considered it fireproof, forgetful that iron was easily worked by heat and it was only necessary to raise the heat to the required point when the iron front would yield. The fact that a higher charge is made when it is not backed up by brick and mortar is due to a loss in New York City, where a fire traveled for a whole block between the iron fronts and the brick wall, which did not come out close to the iron front. Stone walls are charged for because stone yields to heat far more readily than brick. A brick wall will pass through a conflagration withstanding 1,800 or more degrees of heat. Stone will yield to heat at 1,000 degrees and hence represents that much more of a liability to loss.

Roof. The covering to a roof is one of the earliest features which in endeavoring to prevent the sweep of fire even in the colonial days, secured consideration by the authorities. The shingle roof probably as much as any other one cause, has increased the fire loss in the United States. The schedule charges for all forms of roof excepting the metal or the fireproof.

Concealed Spaces. A concealed space in any building means that when the fire starts it will worm its way into this space. This will necessitate, even though the fire be a small one, a large amount of ripping out on the part of the firemen in order to be positive that the last spark has been extinguished. A concealed space stands for an increased fire loss at all times.

Floors. The standard floor is three inches thick, anything less than that being penalized. There undoubtedly exists in a non-fireproof building a very close relation between the thickness of a floor and the character of the protection to the floor openings. The best judgment of today would make the one equal to the other. Ordinary single inch flooring has but very little fire resistance, the more especially when it has been laid for some time and the seams have pulled apart.

Area. Under this item the one point worth noting deals with a principle of schedule rating. A charge for area reaches a certain limit beyond which it cannot go. If the building is under six stories high it may not exceed $1. It is evident where a large number of points are considered in rating a risk, that if each point was allowed to reach its maximum charge, undue emphasis might be placed on certain features or the rate be made altogether out of proportion to what it should be. There are two methods of overcoming this difficulty. One is to provide a decreasing charge under the item, as, for instance, so much for the first ten thousand square feet, a less sum for the next ten thousand and still less for the next. Another way is to provide, as is done in this schedule, what is known as a stop charge where the amount is fixed, beyond which the charge may not go. In connection with the item of area and the item of height, unless the risk be a sprinkled one, it should be pointed out that the judgment of the underwriters, and experience bears this out, is that the charges can hardly be made too high for those points in the schedule.

Height. Four stories are permitted without a charge. Then a charge is made for the fifth, a somewhat higher charge for the sixth, still higher for the seventh and the same charge for each story beyond that. The charges are cumulative. Thus, an eight-story building would have a charge for height of thirty-five cents. It is interesting to note that many underwriters hold the opinion that stocks above five stories high have never been profitable. In connection with the placing of insurance in a seven-story non-fireproof building, a tenant occupied the basement, first floor and seventh floor. The insurance desired was one hundred and twenty thousand dollars, of which all but twenty thousand dollars of the value was in the basement and first floor. The building was not sprinkled. So strong was the feeling against carrying insurance on the seventh floor that that amount of insurance could not be secured with the policies covering over all floors. The problem was solved by dividing the insurance and having it placed so that the policies covered the basement and first floor specifically and then the seventh floor specifically. The small amount required on the seventh floor was obtained in very small policies.

Floor Openings. Floor openings include elevators, stairways, well holes, chutes, vent shafts and dumb-waiters. Fire travels upward; heat rises; it will only spread horizontally when it cannot spread vertically. Floor openings are the most active distributors of fire in a risk. If the floor openings in a building be so protected as to confine the fire on the floor until the fire department arrives, the loss will be immeasurably reduced. The proper protection of floor openings would probably be the second most important factor in reducing the loss of property by fire.

Wood Cornices, Cupolas, etc. All wood parts to a non-fireproof building merely furnish so much additional opportunity for fire to spread or for fire to catch from an adjoining property. The wood cornice is rather an excrescence left over from past ages when the desire to ornament the front of the building or to cover up the drain pipe led to its use. It is an anomaly, of course, to place on a brick wall any wood construction.

Lighting. In regard to electricity it is doubtful if the schedule were being constructed today whether any charge would be made. The hazard from electric lighting and power is one of the best controlled that we have. It is due to the underwriters, that in the very beginning of this most useful invention, they recognized the danger and at once set about the establishment of proper standards to safeguard its installation. Equal credit is due to those who were interested in its development. They have co-operated with the underwriters and the rules of the national association represent the combined judgment of the producers and the insurers. Kerosene always was dangerous and is today unless properly cared for. It is, of course, the most common light that we have, gas being limited to the larger centers where a plant can be supported. The electric light is traveling farther and eventually may come to supplant kerosene; but every kerosene lamp is a potential fire hazard, although the modern lamps are quite safe.

Heating. Fires do not start from buildings; if a fire starts the active agency of heat must be present in some form or must be generated. The most common form in which it is found is in connection with the heating apparatus, whether the heat be used for warming the building, furnishing power, or for cooking. Furnaces which supplant stoves are undoubtedly safer than the stove provided the proper chimney is in the building. When furnaces first commenced to be used they were coupled up to chimneys which had been designed for the ordinary coal stove with the result that the chimneys were overloaded and many fires occurred. The idea is altogether too prominent today that a four-inch or one brick thick chimney is sufficient for the purpose. A chimney should not be less than eight inches thick. A four-inch chimney, with an opportunity for gaps in the joints from which sparks may escape, with the readiness with which a single brick may be warmed through, furnishes a constant danger spot which extends from the lower to the upper floor of the building, not to mention the careless manner in which the beams may be placed against the chimney and in time brought to the point of ignition.

Wires. Wires, either trolley or of other kind, when numerous or heavily charged, will interfere with the work of the fire department and for that reason affect the property adversely. With the tendency which exists today towards burying wires this is one of those charges which will in due time pass away.

Tenants. Charges are provided for the mercantile tenants, meaning in this sense of the word mercantile tenants who do not live on the premises, such as the superintendent of the building or the janitor, nor does it include office tenants. It is customary to include every other tenant who has an insurable interest and which

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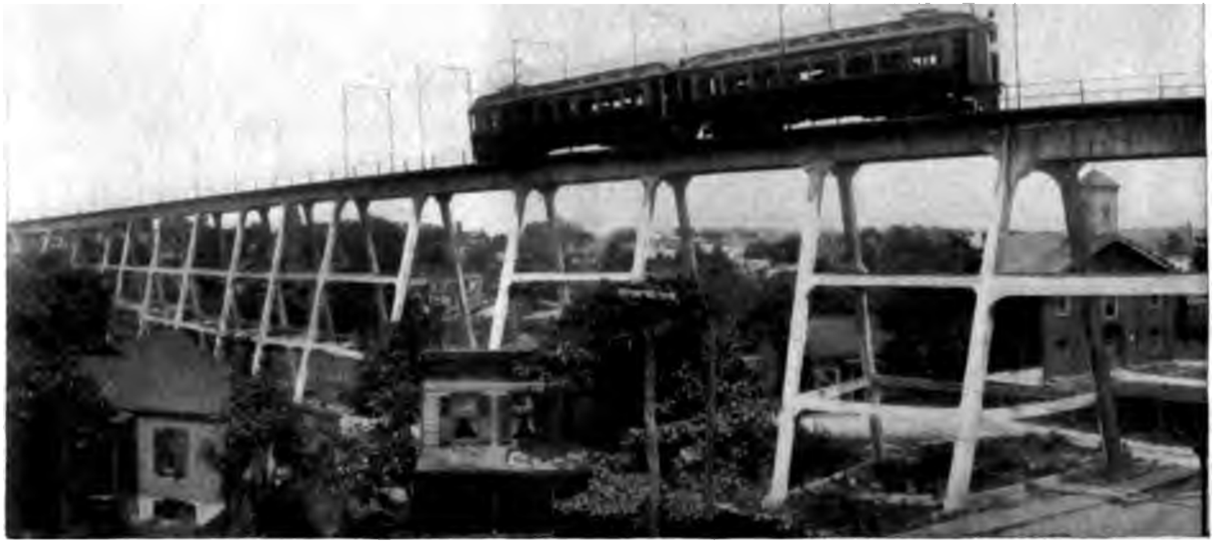

CONCRETE VIADUCT OF RICHMOND & CHESAPEAKE BAY RAILWAY

Interesting Example of Fireproof Viaduct Construction. Kahn System of Reinforced Concrete as Furnished by the Trussed Concrete Steel Company, Detroit, Used in This Construction interest requires a specific rate and the naming of the individual on the card.

Additional charge is provided for the manufacturing tenants who affect the risk more severely than a mercantile tenant does. Every additional tenant in a property means that a portion of the property is subject to that individual control, then as the number of tenants increases the property becomes more and more divided into different independent parts and from an insurance viewpoint less and less desirable. This is true of the mercantile tenants and increasingly true of the manufacturing tenants.

Frame Rears or Extensions. There will frequently be in connection with buildings of ordinary construction a frame extension or even some other small portion which is frame. This is a weakness and is subject to a severe charge.

Stone Piers, Columns, Etc. For the same reason that a stone front is more susceptible to fire than brick, so is a stone pier or column when it is an important carrying member for the support of the building. Brick piers, also, when they have unprotected bond stones or cap stones are subject to being weakened by fire. Figs. 1 and 2 show how the piers were affected in the well-known fire at Cammeyer's in New York City many years ago.

Unprotected Iron Columns or Other Unprotected Metal Members. The iron column directly exposed to the action of fire weakens more readily than the substantial wooden column. These columns can be properly protected and be absolutely safe. But when unprotected they are dangerous.

Steam Boilers. The heating and power apparatus of a property should, in all cases, be cut off from the main part of the risk. It may be impossible to do this in a separate building. It may be done when situated in the basement by enclosing it in a fireproof room or when it is under the sidewalk by cutting it off in a standard manner from the remainder of the basement.

The schedule then provides a series of reductions, made for additional safeguards against fire, which are placed before the owner that he may avail himself of them when he is erecting the property or even when altering it, as has been done in many cases.

Constructional Deductions. Items 119, 120, and 121 offer deductions which aim to secure a floor that will shed water rather

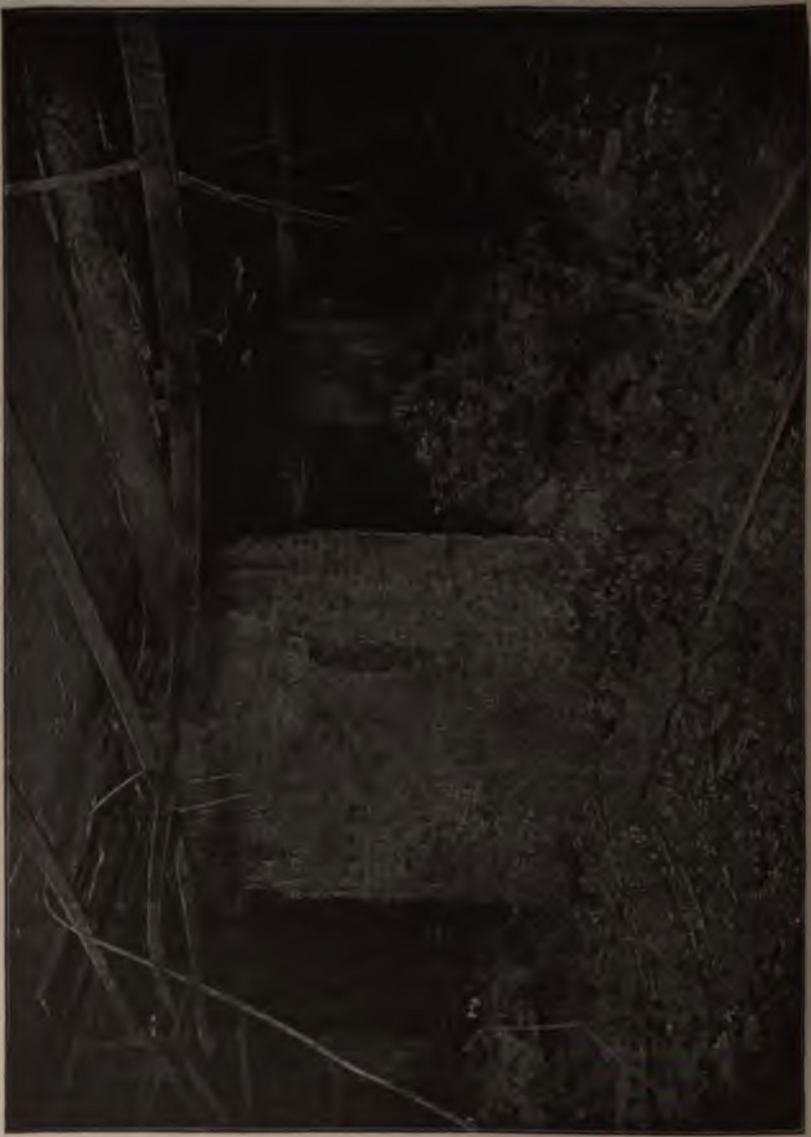

Fig. 1. Effect of Fire on Piers in Cammeyer Building, New York City
Courtesy of Continental Insurance Company

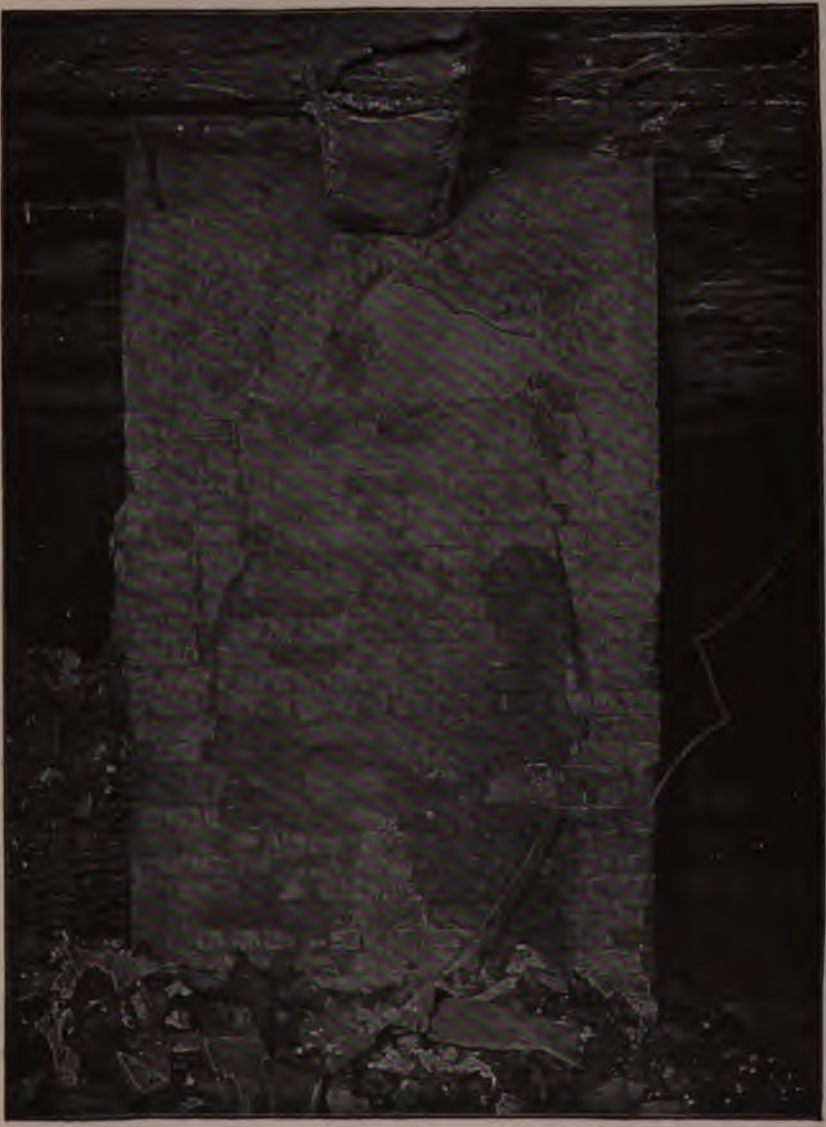

Fig. 2. Effect of Fire on Piers in Cammeyer Building, New York City
Courtesy of Continental Insurance Company

than permit it to pass through onto the stock below. Item 122 provides for an allowance should any floors in the building be of fireproof construction. Not infrequently the first floor is of that type. Items 123 and 124 furnish inducements for making the finish of the building on the side walls somewhat better than the ordinary lath and plaster which is so objectionable because of the concealed spaces behind it, necessitating, as in all concealed spaces, quite an amount of destruction in order to be positive that the fire has been put out, this destruction being over and beyond a damage done directly by the fire. The final reduction is where the timbers in the building are more than twelve inches thick or commence to rise to the standard of mill construction.

Fire Appliance Deductions. The allowances which have just been noted dealt entirely with features of construction. The group which is now to be considered deals with others for which an allowance is made, some, nearly all, being elective on the part of owner or tenant of the property, while others arise from the position of the property with relation to certain factors which will be noted.

Alarms. The automatic fire alarm, the automatic burglar alarm, and the special building signal have in a certain sense, but one purpose to serve, it is their business to transmit to the authorities the fact that there is a fire in the building. Objection would be raised to this statement in regard to the burglar alarm and the objection is fairly well taken, but from an insurance standpoint the burglar alarm is granted an allowance because if property is tampered with in any way by thieves they not infrequently start a fire to cover up the traces of their work; hence, even the burglar alarm is considered of value from the fire point.

The *automatic* fire alarm, as its name implies, acts of itself. When the heat rises to a certain point the alarm operates and gives notice of the trouble. Objections are frequently raised to this device and to others that they operate at times when there is no fire. In the case of the automatic alarm it will frequently ring due to the action of a very hot stove. Technically, this is a false alarm, but it should be pointed out that if the heat of the stove reaches such a point that it operates on the alarm, undoubtedly there is something dangerous in connection with the stove, or the heat would not be so excessive at that point. The action of the alarm would call attention

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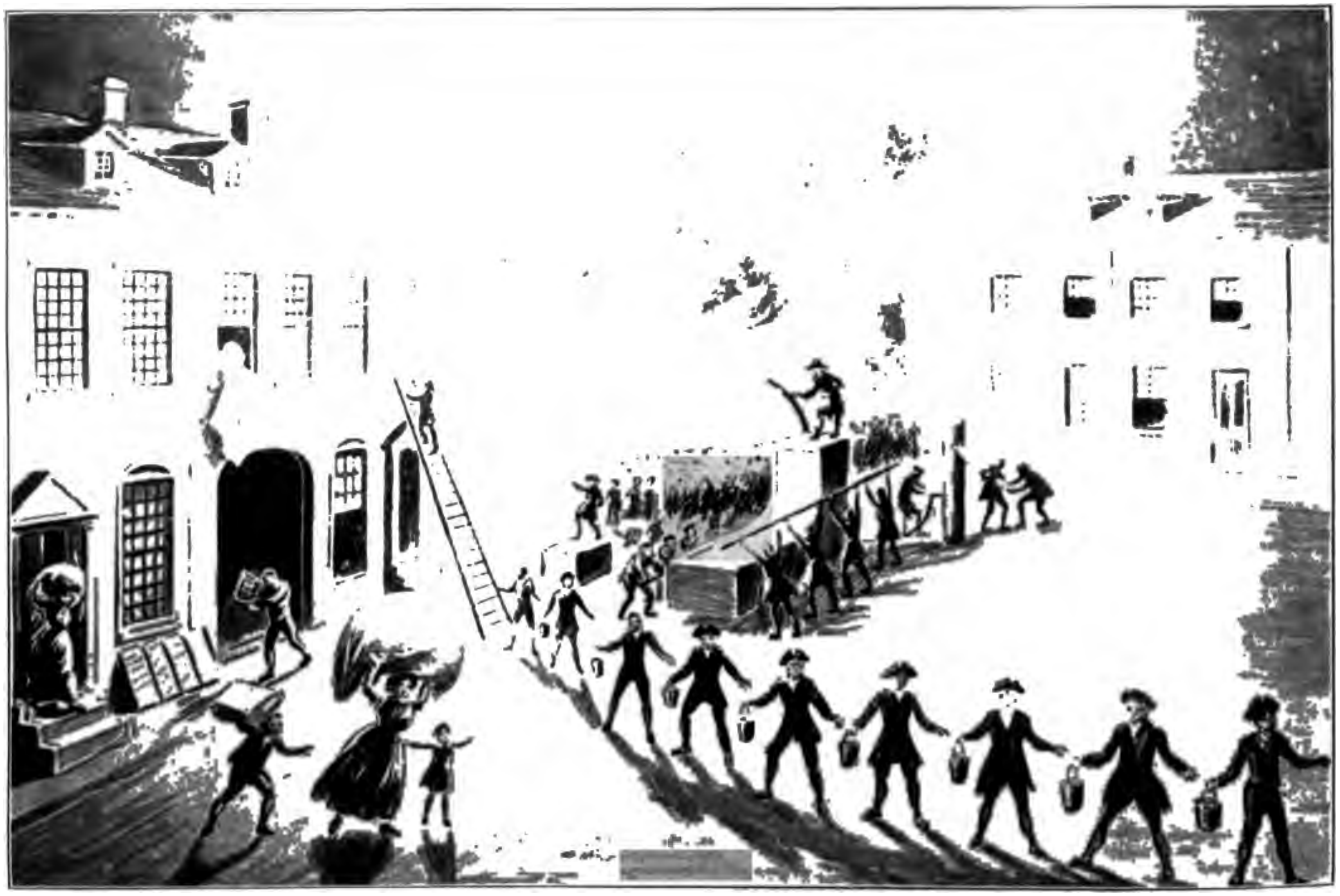

PUTTING OUT A FIRE IN 1800 IN NEW YORK CITY to this defect. One of the troubles, however, which ought to be solved in connection with automatic devices is a tendency to operate falsely or to ring in false alarms. The fire department naturally does not wish to be turned out only to find that there is no real fire. Improvements, however, are steadily being made in such devices and these false alarms will tend to diminish, though probably will never wholly pass away.

One of the earliest means of giving a fire alarm was by a watchman stationed at the top of a tower. On seeing a fire he gave the alarm. Shortly after the invention of telegraphy the method of giving notice of an alarm of fire by means of street boxes was brought into use. Cities were then divided into districts and the alarms were only rung for the district in which the fire occurred. This, of course, is the common system today, but it has this disadvantage in that one street box serves for quite a territory and does not, unless the person who pulls the alarm remains there to direct the firemen, locate the fire. Valuable time is frequently lost in this way. The automatic alarm locates the fire direct in the building. The special building signal does the same thing but it does not operate automatically. Hence, it is a cheaper device for the insured to install. Naturally, as it does not operate automatically it is of no value unless someone is on the premises all the time. During the ordinary business hours it is all right, but when the premises are closed if no watchman is employed the device is valueless. It is for that reason that the allowance is made much larger when the special building signal is installed in a building where watchman service is maintained.

Chemical Engine, Etc. Chemical engines, casks, or pails of water are such well-known devices as to require no comment; probably a third of the fires that start are put out by means of pails of water or ordinary extinguishers. The chemical engine is a device which can be wheeled about from one part of the floor to another, and having nearly a barrel of liquid will serve a much larger and longer purpose in fighting fire than the ordinary hand extinguisher of three gallons.

Standpipes. Standpipes either with or without a tank supply, and roof hydrants serve this purpose; they are on the premises, may be used by the employes before the department arrives, and may be of value to the fire department by avoiding the necessity of carrying hose up many flights of stairs. In the ordinary non-fireproof building, however, standpipes are very rarely found. Forty years ago when standpipes first began to be seriously considered there was a requirement that they should be erected on the outside of buildings. They probably never served any very useful purpose. A department could not operate them and after they had been exposed to the weather for some time they would have burst had water been pumped into them under heavy pressure.

Roof Hydrant. A roof hydrant is not intended for the purpose of fighting fire in the building itself. The use of a roof hydrant is to furnish the means of fighting a fire in another building which is close to the property. In a time of conflagration or a serious exposure to fire the device would be invaluable, provided, of course, the heat was not so intense as to drive anyone off the roof.

Watchman and Clock. From the insurance standpoint the only value of watchman and clock service is in the event of fire or in the prevention of fire; it is probably doubtful whether watchman service, except in some very large plants, is ever installed solely because of the allowance in the insurance rate for that service. It would take an enormous property with a vast amount of insurance to make the allowance of five per cent equal to six hundred dollars, about the minimum amount for which watchmen can be employed. A watchman, however, in connection with properties serves a great many other purposes: the prevention of thievery; prevention of damage, as where water pipes burst; and in the general care and oversight of the property at a time when it is not being used for its ordinary business purposes. The modern office building, for instance, with its acres of space requires some hours before each office can be visited to see that everything has been properly closed for the night and all is well guarded. The service may be brought up to the standard of the underwriting organization having jurisdiction in order to receive the allowance, but where this is done in one case there are undoubtedly dozens of cases where watchman service is maintained but not at the insurance standard.

Fire Escapes. Fire escapes furnish the opportunity of egress to any persons in the building when a fire starts and if the stairways or elevators are not available. They also permit the firemen a foothold in fighting a fire where they cannot enter the building. Life is more valuable than property. Hence, anything which permits the occupants of a building to readily leave it when a fire starts is of direct value to the companies who insure the property, because the firemen, rightly, will pay but little attention to property saving so long as lives are in danger.

The allowance for fire escapes is limited to an allowance for their being on one side of the building. The building may stand on a corner or run through to another street, but additional fire escapes are not deemed of sufficient value to make an increased allowance.

Accessibility. A building may be situated on the corner and thus present two sides from which fire may be fought. It may even stand on the corner and have a street in the rear and thus present three sides. Some buildings, as department stores, occupy whole blocks; hence, a fire may be fought from all four sides. This accessibility, as it is termed, to the fire department is deemed of large value and of increasing value accordingly as more than two sides are accessible; hence, the allowance is made for each side accessible in addition to the front, which, of course, is not given an allowance. It will be noticed that accessibility is something which the building enjoys solely from its location.

Fireboat. The fireboat in the United States is a modern device, though it has been in use in Great Britain at least around the docks in London over fifty years. The first fireboats were undoubtedly somewhat tame affairs compared with the modern powerful boats, but the usefulness of such a device for fighting fires near the water was early recognized. Here, again, as in the case of accessibility, the risk enjoys an advantage solely from its location being near enough to the fireboat. Eight hundred feet measured from the bulkhead to the risk is deemed about the largest distance for which the allowance should be made. Water may be forced through flexible pipes for a longer distance, but that is a safe fire-fighting distance.

Self-Releasing Beams and Girders. At first it might seem as though this was a matter of construction and should have been put with the other construction allowances. It is placed here for the reason that it is of value only to the building. If the building is so far destroyed by fire that the beams and girders give way, the contents are probably totally destroyed when that occurs. But the self-releasing of the beams and girders will leave the walls standing, thus giving the companies that much salvage.

Sprinklers Below Grade. The difficulty of fire fighting below the first floor has led to city ordinances being passed requiring the installation of the old perforated pipes into which water might be forced to fight the fire in that part of the building. The perforated pipes are wholly objectionable, and the inducement is made to the owner to install in their place sprinklers which do not have any water supply but do have a Siamese connection for the fire department to attach to and force the water. The fire, of course, will have opened the head above it and as the water is forced through the pipe it will only come out at that head which has been opened and not the whole length of the pipe as in the case of the perforated pipes. The insured may go beyond this and protect these below grade floors by a sprinkler system having a water supply. In that case a substantial allowance is made rising as high as ten per cent to the building and contents.

Office Occupancy. The building may be occupied for offices or offices coupled with dwellings, or it may have stores on the lower floor and offices and dwellings above. This is naturally a lighter occupancy than even a good mercantile would be and certainly beyond the manufacturing. Hence, the allowances which are very substantial have been provided.

Sprinklers. This deduction for sprinklers at this point means where the building is entirely sprinkled and not that noted above which dealt only with sprinklers for those parts of the building below grade. Only one allowance is made for sprinklers, that is, if they are throughout the property, and that is at this point.

Coinsurance. The schedule up to this point presupposes that coinsurance is not carried, that a policy in fact is what is known and termed a valued policy. If coinsurance is carried, then a reduction is made in the rate. It is assumed that up to twenty per cent of the value of the property coinsurance is of no benefit to the company since the normal loss of non-fireproof buildings would eat up twenty per cent of the value. It is when the insured begins to carry insurance beyond twenty per cent that it becomes of value to the company since the loss will probably be partial and an allowance is made for this additional insurance. Fifteen per cent is deducted for eighty per cent coinsurance. It is based on this rule, namely: One-fourth of one per cent deduction is made in the rate, for each one per cent of coinsurance in addition to twenty per cent. Thus, for eighty per cent coinsurance we have sixty per cent more than twenty per cent; one-fourth of this is fifteen per cent, or the allowance in coinsurance.

Faults of Management. Faults of management include such factors as unprotected stove pipes passing through floors and partitions, and are so called because of the fact that they usually are under the direct control of the insured, *i. e.*, the tenant or management can easily correct the defect. In some properties this will be so bad that eight or nine of these charges may be made. Attention should be given to the fact that the charges are extremely heavy, that they are put at the very bottom of the rate and are not subject to any coinsurance or other allowances. This is due to the fact that it is the desire of the insurer to have them corrected. The charge will generally accomplish this desire. By being placed at the very bottom of the rate they can be removed without a recomputation and save that much time and expense to all concerned.

CONTENTS RATE

Relation to Building Key Rates. In computing the rate of the contents, there are not so many different points to be noted as might be supposed. The rate is taken at point 127a, a certain deduction is made at point 128 and the remainder is considered the key rate for the contents. A list of occupancies is furnished in the rate book and whatever the tenant's business or the material dealt in happens to be, the charge for it is taken. It may be dry goods; it may be wholesale groceries; the tenant may occupy the entire building with a stock uniformly distributed—or fairly so—over the various floors. It has been noted earlier that stocks that go above the grade are less desirable. The fire department cannot handle the fire as easily, and they are generally more subject to loss. Hence, an additional charge is made for each floor above the first or below it, for that matter, on which the stock may be located. Thus, if the stock is on the fifth floor there would be a charge of four times five cents or twenty cents for the location of the stock. If the stock is distributed over more than one floor, as the second and third, these charges are added together and divided by the number of floors; thus, the second floor has a charge of five cents, the third floor ten cents, fifteen cents for both and a tenant occupying the second and third floor would have half this charge or seven cents and a half. The key rate of the contents, the proper charge for the occupancy and the height of stock above grade are then added, after which reductions are made as in the rate of the building and do not call for any consideration except where they differ from this rate. These differences are in items 213, 214, and 215.

Deductions. *Merchandise Covered by Tarpaulins.* The first is merchandise covered by tarpaulins each night, and in an experience covering several thousand properties, it has not been the writer's good fortune to find one case where an allowance has been made for these covers being provided. To accomplish the purpose of the underwriter, that is, protect the stock from water damage, the covers would necessarily have to be quite heavy and treated with oil in order to shed water. Such a cover, or tarpaulin as the nautical phrase is, would ruin a great many stocks. The difficulties, therefore, of meeting the underwriters' requirements on the one hand and of avoiding damage to the stock on the other, appear to be unsurmountable.

Merchandise in Tin-Covered Cases. It will not infrequently happen that merchandise will be in such container, or even provided with such covers that an allowance is due. A certain brand of cocoa which is imported from abroad comes in individual tin packages. These are then packed in a large tin case and this large tin case is put in a large wood case, the whole, of course, making a very good protection from water damage at least. This is a case where the allowance was granted, although the tins were not made purposely as is done in some cases to secure the allowance.

Skids. If merchandise is in packages and the nature of the package is such that it will be some protection from water damage to the stock, then there is a value if the stock is some distance above the floor; six inches is accepted as a standard. This will permit during a fire a certain amount of water to be thrown in the building, which water being shed by the package, would run off onto the floor and have a depth of six inches to fill up before the stock would be standing in the water. It is of no special value in the case of an open stock.

Grade Floor Stock. Stocks on the first floor are still considered the most desirable, probably, of any in the building. They can be in the case of fire so easily reached by the patrol and protected. A heavy loss above may be very light below. If entirely on the grade floor, that is the most desirable. If extending over one additional floor, either the basement or second, and skidded on the lower floor, an allowance is made but still a less allowance than when the stock is wholly on the first floor. The stock need not be in the original package to obtain this allowance, as in the case of 216, where the allowance of skids only applies when the stock is in a substantial package.

It is well to emphasize the fact that the possible allowances foot up a very substantial total, running up to fifty per cent should the building be fortunately situated and equipped.

Merchandise Stock in General. The only further point worthy of special notice in connection with the contents of a building is that the allowance for coinsurance is seven and one-half per cent, or one-half that made for the building. Increased insurance on the contents is not as desirable as in the case of the building; their greater susceptibility to damage being the reason for this discrimination.

SPECIAL FEATURES

The general review of the schedule just given is probably sufficient for all practical purposes when taken in connection with the examples of actual rating which are given on page 69. There are a few points in connection with the schedule, however, which call for a somewhat fuller discussion than the general running comment which they have so far received.

Occupancy. The first of these is the division for the charge of occupancy into two items. At point 127*a* the schedule states that fifty per cent of the amount in first column charge for the most hazardous occupancy is to be taken. The schedule furnishes a list of occupancies beginning with the number 400 and ending with 1,687, thus listing 1,287 different businesses. There are actually more than this since there are some, as department stores, coffee dealers, and groceries, that are divided into several sub-classes. The division of the charge for occupancy into two parts, a first column and a second column, is made for *ignibility* and *susceptibility*, respectively.

Until the universal mercantile schedule was brought forth this division of the occupancy into these two parts, while it may have been recognized, had never been put into actual practice. It is now an accepted principle, however, in the fire insurance business and has even been carried a point further in the analytical system which is discussed in Part III.

To take a concrete case, it will be readily seen that gunpowder has an equal degree of ignibility and susceptibility for a very slight thing might set off gunpowder, and once set off, the entire mass would be destroyed. Hence, in rating, the same charge would be made under each column. In the case of a stock of pig iron, for instance, even the wildest imagination could not conceive of pig iron starting a fire. Hence, ignibility does not exist and no charge would be made. There might be some susceptibility to damage; with the fire once started there would be, and a charge would be made, but it would be a very low one.

A third example which will furnish an illustration of the lack of ignibility with a high degree of susceptibility is found in the case of kid gloves. In ordinary insurance use the term "kid glove" covers gloves made from almost any kind of skin. In buying and selling the term is probably limited to the finer hand glove, but from an insurance standpoint, which is the standpoint that is of interest now, the phrase "kid glove" would have rather a wide range. The kid glove does not possess ignibility, but it is, however, one of the most extremely sensitive articles to water damage. An instance occurred of an actual loss where the fire was confined to the front part of the loft. Not even water reached the rear part of the loft. The insured were positive that the kid gloves had all been damaged or at least a great part of them. Shortly after the fire when the claim was made the gloves were examined and did not betray any signs of defect. The insured told the company's representatives that he would hold the gloves for two or three weeks and he would satisfy them that the gloves were damaged. In due course he called for the company's representatives to visit the premises and demonstrated to them that a certain amount of mould which was caused by the dampness had gathered on the gloves. The mould was hardly discernible to the naked eye but could be seen through a glass. Extreme cases have perhaps been taken and the mean runs between these cases, but enough has possibly been stated to show this important principle of considering the occupancy of the building from these two points, namely, how likely is this occupancy to cause a fire and if a fire is started how much will the contents be damaged?

Exposure. *Old Method.* Another point deserving of a fuller treatment is the matter of exposure. Damage by fire caused by a fire outside of the risk is an exposure fire. Up to the time of the mercantile schedule it was recognized that where a building did not stand actually detached from all other properties, at least one hundred feet on all sides, there was a certain liability to fire caused by the nearness of the properties. But the computation of the charge was based on a somewhat rough percentage system. If a risk of a very mild character stood adjoining one of a very high hazard the rate for the two would be made the same. Thus, a dwelling house next to a saw mill might take the rate of the saw mill; or lumber in the yard of a saw mill directly adjoining would take the rate of the saw mill. As the distance between the properties increased the rate for the milder hazard would decrease also, generally running out entirely at one hundred feet. This method of computing the charge was crude—no other word expresses it. It rather ignored all other factors except that of distance.

Universal System. The mercantile schedule has a very highly developed exposure table which can be clearly seen by studying the reproduced table on page 67. The building may be exposed on each of its four sides, front, right, rear, and left. The first facts gathered consider height, rate, distance, and the length of the exposing side for each of the properties that expose the risk. Should any of these properties be situated one hundred feet distant, no exposure charge is made against the risk from that side. For any distance less than that an exposure charge is made. Tables are provided dealing with risks which are under protection, pages 67 and 68, meaning thereby risks which are situated at points or in cities where there is a fire department and water supply; and others dealing with risks which are not under protection.

The only difference between the two tables is that in the unprotected case the charges are about twenty-five per cent higher than they are in the protected. The protected risks, therefore, will serve as an illustration without taking up the unprotected.

Another important division is then made, viz, on the basis of whether the exposure adjoins the risk or is separate from it; this is done in both the protected and unprotected cases. Assuming that the rate of the exposure on any one side is one dollar and that the separation from the risk is ten feet, then a charge is made of two-tenths of one per cent of the exposure rate for each foot that the distance is less than one hundred feet. In this case the rate of the exposure was one dollar, and the distance ten feet, or ninety feet less than one hundred feet; ninety times two-tenths of one dollar gives one hundred and eighty-tenths or eighteen cents. This charge of eighteen cents constitutes the initial charge and is placed directly beneath the heavy black lines at the top of the exposure table. The other points which are noted on the exposure table are then taken up and considered. Thus, should there be a blank wall of the risk toward the exposure for the given side, four-fifths of this initial charge is to be deducted. This simply means that a solid brick wall is deemed worth, at this point, an allowance of eighty per cent in the exposure from that side. The various other factors are considered in due order. The rule laid down is the method of computing a charge where the difference between the rate of the risk and the rate of the exposure is less than fifty cents.

If the rate of the exposure exceeds the rate of the risk by more than fifty cents, the initial charge is computed in this manner. Take such a percentage of the initial charge as equals the rate of the risk and then from the excess table take the additional charge. As an illustration, assume that the rate of the exposure is two dollars and the rate of the risk is one dollar. In this case we have a difference of one dollar and must use both tables. We may assume also that the distance is ten feet and thus use eighteen cents as the initial charge, having already found that eighteen cents is the initial charge for a one dollar exposure rate. But there is left of the exposure rate one dollar which has not been used in the exposure charge and for this there must be added one-tenth of one per cent for each one dollar of rate that the exposure exceeds that of the risk. In the first table there is added two-tenths of one per cent for each foot of deficiency. In this table it is one-tenth. Hence, at ten feet, if eighteen cents were added in the first table, nine cents would be added in this table, so the initial charge now would be eighteen cents plus nine cents, or twenty-seven cents, and then this twenty-seven cents would be subject to analysis by the various items provided in the exposure table.

In practice, after the rate is computed for the four sides, it is customary to deduct a certain amount—ten per cent is a fair sum—and charge the balance in the rate. This deduction is made as a general working margin since it avoids recomputation of the exposure charge for every trifling change that may take place in the exposing properties. The exposure chart, page 48, sets forth all the points which have to be taken into consideration except the initial charges, which are here shown complete.

EXPOSURE TABLES, A, B, E, and F

TABLE A.

PROTECTED RISKS—SEPARATED

(*i. e. within* 500 *feet of hydrants.*)

BRICK BUILDINGS BY BRICK BUILDINGS WITH OPENINGS

Exposure Distance or Separating Space	Rate of Exposure 100 cents	Rate of Exposure 200 cents	Rate of Exposure 300 cents	Rate of Exposure 400 cents	Rate of Exposure 500 cents	Rate of Exposure 600 cents	Rate of Exposure 700 cents
	AMOUNT TO BE ADDED FOR EXPOSURE						
10 feet.	.18 cts	.36 cts	.54 cts	.72 cts	.90 cts	1.08 cts	1.26 cts
20 "	.16 "	.32 "	.48 "	.64 "	.80 "	.96 "	1.12 "
30 "	.14 "	.28 "	.42 "	.56 "	.70 "	.84 "	.98 "
40 "	.12 "	.24 "	.36 "	.48 "	.60 "	.72 "	.84 "
50 "	.10 "	.20 "	.30 "	.40 "	.50 "	.60 "	.70 "
60 "	.08 "	.16 "	.24 "	.32 "	.40 "	.48 "	.56 "
70 "	.06 "	.12 "	.18 "	.24 "	.30 "	.36 "	.42 "
80 "	.04 "	.08 "	.12 "	.16 "	.20 "	.24 "	.28 "
90 "	.02 "	.04 "	.06 "	.08 "	.10 "	.12 "	.14 "
100 "	.00 "	.00 "	.00 "	.00 "	.00 "	.00 "	.00 "

If the rate be less than 1%, *reduce pro-rata.*
RULE: **If the rate of the exposure does not exceed that of the risk** *by more than* 50 *cents, add the amount named in the above table, A, for the given distance.*

If the rate of the exposure exceeds that of the risk *by more than* 50 *cents, add the amount named in the above table for so much of the rate of the exposure as equals the rate of the risk itself, and also the amount for the given distance in the following table for such amount as the exposure exceeds the rate of the risk.*

For example, if a 2% risk exposes a 1% risk at 20 feet, the amount named for 1% in the above table opposite 20 feet is 16 cents, and in Table B below for 100 cents excess is 8 cents, making a total of 24 cents. If a 3% risk exposes a 2% risk, the amount for 2% in Table A above at 20 feet is 32 cents, and for 100 cents excess in Table B below is 8 cents, making a total of 40 cents. Thus the rate of the risk would be 2.40. The exposed rate of the 3% risk would be that of 200 cents in Table A at 20 feet, 32 cents, making total exposed rate 3.32.

IF RISK HAS BLANK WALL toward exposure deduct four-fifths amounts named in Tables. If risk has openings, but EXPOSURE HAS BLANK WALL toward risk, deduct one-half amounts named in the Tables.

IF BOTH WALLS BLANK, deduct ninety per cent of amount named in Tables.

IF OPENINGS NOT OPPOSITE each other, deduct 30%. If openings on grade floor only, deduct 25%.

For FIRE SHUTTERS to the risk deduct 50% of charge.
" " " " exposure " 30% " "
" " " " both risk
and exposure " 60% " "

If intervening distance exceeds 40 feet increase the percentage of deduction by 1% for each foot that the distance exceeds 40 feet, not exceeding a total deduction of 90%.

TABLE B. Exposure Distance or Separating Space	**ADD TO ABOVE FOR EXCESS OF EXPOSURE RATE**						
	Add for 100 cents excess	Add for 200 cents excess	Add for 300 cents excess	Add for 400 cents excess	Add for 500 cents excess	Add for 600 cents excess	Add for 700 cents excess
10 feet.	.09 cts	.36 cts	.81 cts	1.44 cts	2.25 cts	3.24 cts	4.41 cts
20 "	.08 "	.32 "	.72 "	1.28 "	2.00 "	2.88 "	3.92 "
30 "	.07 "	.28 "	.63 "	1.12 "	1.75 "	2.52 "	3.43 "
40 "	.06 "	.24 "	.54 "	.96 "	1.50 "	2.16 "	2.94 "
50 "	.05 "	.20 "	.45 "	.80 "	1.25 "	1.80 "	2.45 "
60 "	.04 "	.16 "	.36 "	.64 "	1.00 "	1.44 "	1.96 "
70 "	.03 "	.12 "	.27 "	.48 "	.75 "	1.08 "	1.47 "
80 "	.02 "	.08 "	.18 "	.32 "	.50 "	.72 "	.98 "
90 "	.01 "	.04 "	.09 "	.16 "	.25 "	.36 "	.49 "
100 "	.00 "	.00 "	.00 "	.00 "	.00 "	.00 "	.00 "

TABLE E. PROTECTED RISKS—ADJOINING

BUILDINGS **ADJOINING***	Rate of Exp're 100 cts	Rate of Exp're 200 cts	Rate of Exp're 300 cts	Rate of Exp're 400 cts	Rate of Exp're 500 cts	Rate of Exp're 600 cts	Rate of Exp're 700 cts
	AMOUNT TO BE ADDED FOR EXPOSURE						
Walls not Deficient exceeding 10 cents under Nos. 38 or 39.	cents .02	cents .04	cents .12	cents .16	cents .20	cents .24	cents .28
Walls Deficient exceeding 10 cents under 38 or 39.	.06	.12	.18	.24	.30	.36	.42
If one wall deficient one-half chg.	.03	.06	.09	.12	.15	.18	.21
Wall Higher and openings in excess height, on higher building.	.08	.24	.36	.48	.60	.72	.84
Charge on lower building.	.02	.10	.15	.20	.25	.30	.35
Buildings Communicating on the grade floor with single fire door.	.08	.16	.42	.56	.70	.84	.98
If above grade floor " " "	.14	.28	.54	.72	.90	1.08	1.26
(If double doors, one-half charges.) N. B.—No deduction for Fire-Doors, if exposure be an Oil or "Grease" risk—rate as one hazard.							
Party Wall with deficiencies not over 24 cents under 40 or 41.	.03	.06	.18	.24	.30	.36	.42
Party Wall if deficiencies exceed 24 cents under 40 and 41, or if any portion of wall is less than 12 inches thick.	.08	.16	.24	.32	.40	.48	.56

Wall Longer or Shorter, openings being at right angles, charge one-fourth of what would be charge for distance between nearest openings by tables A and B.

**Where the Occupancy Table first column charge of the adjoining exposure exceeds that of the risk, add one-sixth of the excess to above charges unless the separating walls are independent, without communications and carried above roof.*

RULE: **If the rate of the exposure does not exceed that of the risk** ***by more than*** *50 cents, add the amount named in the above table.*

If the rate of the exposure exceeds that of the risk *by more than 50 cents, add the amount named in the above table for so much of the rate of the exposure as equals the rate of the risk itself, and also the amount for the deficiency in the following table for such amount as the exposure exceeds that of the risk.*

TABLE F.

BUILDINGS **ADJOINING**	Add to Above for Excess of Exposure Rate						
	Add for 100 cts excess	Add for 200 cts excess	Add for 300 cts excess	Add for 400 cts excess	Add for 500 cts excess	Add for 600 cts excess	Add for 700 cts excess
Walls not Deficient exceeding 10 cents under Nos. 38 or 39.	cents .03	cents .15	cents .45	cents .80	cents 1.25	cents 1.80	cents 2.45
Walls Deficient exceeding 10 cents under 38 or 39.	.08	.32	.72	1.28	2.00	2.88	3.92
If one wall deficient one half chg.	.04	.16	.36	1.14	1.00	1.44	1.96
Wall Higher and openings in excess height charge on higher bldg.	.08	.24	.54	.96	1.50	2.16	2.94
Charge on lower building.	.02	.10	.15	.20	.25	.30	.35
Buildings Communicating on the grade floor with single fire door.	.06	.28	.63	2.12	2.75	3.52	4.43
If above grade floor " " "	.18	.62	1.89	2.44	3.25	4.24	5.41
(If double doors, one-half charges.)							
Party Wall with deficiencies not over 24 cents under 40 or 41.	.06	.20	.54	.96	1.50	2.16	2.94
Party Wall if deficiencies exceed 24 cents under 40 and 41, or if any portion of wall is less than 12 inches thick.	.09	.36	.81	1.44	2.25	3.24	4.41

ILLUSTRATIVE EXAMPLE

One of the most profitable methods of examining the subject of rating will be to take a few actual examples. A report for the rates has been made on the categorical blank shown on page 6 in Inspection, Part I.

Preliminary Charges. *Key Rate.* The key rate is fixed at 20 cents for the city and calls for no labor.

Walls. The first item that calls for specific consideration is the walls which are treated in the items running from 38 to 46½, inclusive. The report shows the building to be eight stories in height; all four of the walls are independent. The thickness of the right wall on the first floor is sixteen inches and twelve inches for all floors above; the left wall twenty-eight inches for the first and second floors, twenty inches for the third, sixteen inches for the fourth, and twelve inches for each floor above that. It is evident that the weaker wall is the right wall and that is the one that will be charged for in the schedule. The walls in this case do not come up to the code standard.

A deficiency charge is due and this deficiency charge is based on the difference between the wall as it is and the wall called for by the standard in the schedule. A standard independent wall should be twelve inches at the top story and increased four inches for each story to the bottom, or an average thickness throughout of twenty-six inches. The right wall in the risk is twelve inches for seven stories or eighty-four inches in all, and sixteen inches for the first story, making one hundred inches for the eight stories or an average of twelve and one-half inches for each story. Inasmuch as the requirement is twenty-six inches and the building has only twelve inches there is a deficiency of fourteen inches. The charge is one cent under item 38 for each four inches variation from the standard. Four into fourteen would go three and one-half times, thus making a charge of three and one-half cents if we could stop our operation there, but under item 38 where the building is above three stories high the charge would be double, hence, this would make a charge of seven cents, but under item 39 there is a note to the effect that where two independent walls adjoin, four inches must be deducted from the average requirement. That is the case in this instance; two independent walls adjoin, hence our average requirement would not be twenty-six inches but twenty-two, whereas we have twelve, leaving a deficiency of ten inches, which would make a charge of two and one-half cents, being one cent for each four inches deficiency, but as the building is over three stories high this charge may be doubled and would give a charge under item 38 of five cents. None of the other deficiency charges called for under walls apply.

Roof. The next point to be considered is the roof and the inspection report states that the roof is slag, a type of composition, and the charge under 47 is one cent.

Area. Area is next subject to consideration. The building has five thousand seven hundred square feet; two thousand five hundred are allowed without charge, leaving three thousand two hundred to be charged for at three cents for one thousand square feet or at that rate for any fraction of less than one thousand, thus making a charge of .096.

Height. The height is eight stories; the fifth story is three cents, the sixth story is five cents, the seventh story twelve cents and the eighth story fifteen cents, a total charge for height of thirty-five cents.

Floor Openings. Elevators and stairways have each three series of charges to provide for different conditions. The inspection report gives the information that there are two elevators in the building and two flights of stairs. The elevator and one of the stairways adjoin, the other stairway being in another part of the building. It is only permitted to make the full charge for one elevator and stairway with quarter charges for any additional elevators or stairways; the condition which will furnish the higher charge, naturally the poorer condition, must be taken for the first charge. Taking the elevator, it is found in a brick shaft with two and one-half inch doors on an inclined track with a fusible link; in other words, a standard elevator for which no charge could be made. Then the stairways must be considered to determine which is the proper one to be charged for. There is one flight of stairs through the roof in a brick shaft adjoining the elevator, iron stairs, kalamein and wire-glass doors to fire escapes. The second flight of stairs runs from the first to the sixth floor and is open, from the sixth to the seventh is boxed in wood and has the ordinary wood and glass doors to the loft. There is an additional flight from third to fourth floors. The poorest condition then is the open flight of stairs. Under item 73 an open flight of stairs throughout the building makes a charge of eight cents, but in this case the open flight runs from the first to the sixth floor or it pierces five-sevenths of the building; hence, our charge is five-sevenths of eight cents or .057. The continuation of this flight is enclosed in wood with ordinary doors and would be chargeable under item 71, six cents, but as it is only one flight, one-seventh of six cents or .009. There is an additional flight of stairs running from the third to the fourth floor open, the proper charge is one-seventh of eight cents or .011, but as this is an additional flight only one-fourth of the full charge may be taken which amounts to .003. Adding these various items together the total for the stairways is .069. This is an excellent illustration of how minutely the charge may be computed concerning certain items of a risk. The prorating of these charges according to the number of floors that are pierced by the openings is always figured down to the final mill.

Other floor openings are to be charged for and the only one appearing from the survey is a well hole 11½ × 14 feet piercing the third floor. The charge under item 74 is five cents.

Skylights. Skylights are found to be over openings seven and one-half feet square one-fourth inch glass on metal. Over the main building there are three 11½ feet × 6 feet × 18 inches which are wire glass on metal. The three over the main building are standard. Those over the elevator are wrong, the deficiency being in the lack of the metal screen above the thin glass. The screen is for the purpose of preventing burning brands falling into the building. A charge is made until the screen is provided. There are fifty-seven square feet; nine are permitted without charge, leaving forty-eight to be charged for. The charge is two cents for each nine square feet in excess of nine, not exceeding a total of fifteen cents. The charge is .104.

Lighting. The lighting is electric. One cent under item 84. The number of tenants in the building is three and a three cent charge is made under item 106.

Iron Columns. Iron columns of which there appear to be several on the first floor, 12″×12″, charge ten cents under item 110.

Boiler. The boiler which furnishes heat and power is cut off from the building, it being under the sidewalk, but the door is in a very poor condition, so a charge is made under item 111 until the conditions are made standard.

This completes the series of items which have to be considered before the first group of reductions. The charges made up to this point are:

Key rate			.20
Walls	Item	38	.04
Roof	"	47	.01
Area	"	59	.096
Height	"	63 to 5	.35
Stairways	"	71 to 3	.069
Well holes	"	74...3	.05
Skylights	"	76	.107
Electric light	"	84	.01
Tenants	"	106	.03
Unprotected columns	"	110	.10
Boiler	"	111	.05
Total			1.112

Reductions. Under reductions the posts and girders on the lower floors are 15″×15″; on the middle floors 11½″×11½″ and on the upper floors 9½″×9½″. The beams are 11″×14″ and 10″×12″. Some of the posts and girders are a little below standard but the general condition is so good that the rater is justified in making allowance under item 125 for the post, beams, and girders being not less than twelve inches thick. Five per cent deducted from the 1.112 leaves a balance to be carried forward of 1.066. The tenant with the highest first column charge which must be considered at 127*a* has furniture stored on the premises and comes under occupancy number 603, 25/100. One-half of this charge being in use for the territory where the schedule applies, twelve and one-half cents is added to the amount brought over, making a total of .091. No allowances apply.

Final Building Rate. Exposure has been computed on the table and shows forty-four cents, making the total at this point 1.631. Deducting the 15% for coinsurance or .244 and there is a final rate on the building of 1.387. To recapitulate from the point where the first addition was made shows the following results:

First total	1.122
Item 125, deduct 5%	.056
Remainder	1.066
Add 50% of first column charge, 127*a*	.125
Total	1.191
Add item 130, exposure	.44
Total	1.631
Deduct 132 coinsurance 15%	.244
Final rate	1.387

Effect of Possible Improvements. Before taking up the rate of the contents of one tenant it will be well to examine the schedule as thus computed to see what charges may be removable that will reduce the rate. The key rate may not be altered without a general change in the city conditions. The walls in order to be brought to standard would call for a large expenditure and that may be regarded as not feasible. A small charge of one cent for the roof would not be a profitable investment, but when the roof wears out the matter of a possible charge should be borne in mind and the standard roof put on the building. Area is a question of fact, the building either has or has not the number of square feet which the inspector has reported. It is not a debatable point, as it can always be measured by the tape. The remarks concerning area being a question of fact applied to many items.

The stairways next call for consideration and it is possible to place a standard shaft in the building with standard doors and have the charge entirely removed. The well hole might be done away with, probably could, as light can be so readily furnished now by means of electricity. The skylight without doubt can be made standard and that charge removed. Electric light has a fixed charge, likewise the number of tenants, the unprotected iron posts can be properly protected and the ten cent charge disappear. Finally, the charge for the boiler can be removed by standardizing the doors which cut the boiler off from the remainder of the property; hence, it is found that of the amount at the first total 1.122, .376 furnishes the opportunity for corrections and the reduction of the rate at that point by that amount, so that of 1.122 there would only remain .746. This illustrates one of the objects of schedule rating which aims to credit the good things and penalize the bad, and is only too glad when the bad are brought to a standard which will permit of the charge being cancelled.

Fire pails may be installed; they always pay for themselves in the reduced insurance rate and a large number of the other items are worthy of consideration, but at least five per cent of the rate at the point where the allowance is made is subject to removal for fire pails. The area of a property is five thousand seven hundred square feet, which would call for twelve pails installed on each floor. There is no basement or sub-basement. Pails can be purchased at from three dollars to four dollars a dozen and the cost of stands or hooks to place them on would probably run not more than one dollar per dozen. At the outside, fifty dollars would equip the building in a standard manner with fire pails and this allowance of course would apply not only in the rate of insurance on the building but also on the contents.

Contents Rate. There are three tenants in the building, two of them being of small moment occupying but a small part of the premises, while the main tenant occupies the first, second, third, fourth, and eighth floors. The principal tenant has a storage of wire with a small amount of work and a storage of household furniture, the occupancy charge being fixed at 25c–$1.

The key rate for the occupancy is determined in the following manner: At point 127*a* the amount is 1.191. This includes all the building charges plus the hazard charge for the most hazardous tenant in the building. The schedule considers that the entire deficiency charges of the property should not apply to the contents and makes a reduction of ten per cent from these deficiencies. Now the deficiencies of the building are the amounts at 127 less the key rate which of course is not a deficiency. A perfect building, in other words, would have no charges against it; hence, any charges that are made are deficiency charges.

The amount at point 127 is 1.066; deducting the twenty cents and it is .866; ten per cent of this is .0866. But as the work is only carried to three points beyond the decimal it becomes .087, the fourth point being dropped if it is below five, but adding one to the third point if it is five or over. The amount at 127*a* is 1.191 less ten per cent of the deficiency charges or .086, leaving as the key rate of the contents 1.105. There must be added seventy-five per cent of the second column of the stock to be rated which is that of furniture with a second column charge of one dollar and the amount added is seventy-five cents. The stock must now be charged according to its location on the different floors. It is found on the first, second, third, fourth, and eighth. There is no charge for stock on the first floor; on the second the charge is five cents; on the third it is ten cents and on the fourth it is fifteen cents, while on the eighth it is thirty-five cents. The sum total of these charges is sixty-five cents. But the stock is distributed over five floors so the insured is entitled to this distribution of the stock which is of advantage to the insurer. Five into sixty-five goes thirteen times. A total then at this point is made up as follows:

Key rate for contents	1.105
Occupancy charge	.75
Height above grade	.13
Total	1.985

No allowances apply, but any item for which an allowance can be made should be taken up by the parties in interest to see if the reduced insurance would not more than pay for their installation. The exposure (44) must now be added to the 1.985 and the next total is 2.425; deducting coinsurance of seven and one-half per cent or .181 and the final rate is 2.244.

Final Analysis of Rate. This is the normal process of computing a rate. It is an analysis according to the facts presented by the inspector's report and the charges called for by the schedule. The proper consideration of the various items in the case is one which requires a certain nice discrimination and at times becomes more a question of equity than it does of what the schedule demands. In schedule rating, as in a great many other things, "The letter killeth but the spirit maketh life."

It will have been noticed that if the improvements which may be made in regard to deficiency construction features are carried out the key rate of the contents will profit just as much as the rate on the building, since the two work together. It is also worthy of more than passing notice that it is the height which is the great factor in making the rate of insurance on this property so high. Of the total charges at the first footing of 1.122, thirty-five cents comes from height and when these charges are reduced as they might be by various reductions suggested and there remains at the first footing .746 the height charge of thirty-five cents furnishes about one-half of the rate and yet this extreme penalization of height is in accord with the best underwriting judgment throughout the world.

Exposure. The exposure table must be given further consideration in our analysis of the process of rate making. In the rate of insurance forty-four cents has been given as the exposure charge. The table on which it is computed shows that this charge is made up in the following manner:

The front is not subject to any exposure charge, there being no exposing property within one hundred feet. On the right there is a two-story building with a rate of seventy-five cents at a distance of twenty-five feet, having a length of side of thirty feet. This is all the necessary information required to commence computing the exposure. The rate of the building at that point before the exposure is added is 1.191. The rate of the exposure is seventy-five cents. The full charge will be made under the first table. The distance is twenty-five feet or a deficiency of seventy-five feet. At twenty feet the initial charge for one dollar of exposure would be sixteen cents; at thirty feet it is fourteen cents; hence, as twenty-five is midway, the initial charge is fifteen cents. But the exposure has a rate of seventy-five cents, not one dollar, so three-fourths of fifteen cents is taken as the initial charge, or .113. Examining the conditions it is found that no item applies until the length of the exposed side of risk is reached and this is thirty-five or forty feet less than seventy-five feet. It is considered that the heat which may be generated by seventy-five feet length is about the maximum.

That is, a building with that length of side on fire represents the maximum degree of heat which may be generated, and if the property exposed presents less than that front to the exposure it is considered an advantage, and the same is true if the exposure itself is less than seventy-five feet.

Therefore, from .113 under the length of exposed side of risk forty per cent may be deducted or .045, leaving .068. The exposure has a length of side of twenty-five or fifty feet less than seventy-five. A deduction, therefore, is one per cent for each two feet; hence, there is twenty-five per cent deduction from the .068 which equals .017 leaving .051.

Height of exposure is the next item to be considered. The exposure is only two stories high and ten per cent is deducted for each story less than five; hence, thirty per cent would be deducted in this case, or .015 leaving .036. No other items apply and the amount is brought down to the bottom of the column .036.

It will be noted here that *shutters* would make an exceptionally substantial reduction from this side, but it should also be pointed out that the exposure from this side started with an initial charge of .113 and has been reduced to about one-fourth of that amount by the permissible reductions. The exposure in the rear comes from a four-story building at a distance of ten feet with a rate of sixty-five cents. It is more than seventy-five feet in length and likewise the risk itself is more than seventy-five feet exposed on this side. The initial charge here is taken from the first table. At ten feet if the exposing rate was one dollar it would be eighteen cents, but the exposing rate is only sixty-five cents, so that percentage is taken for the initial charge or .117. No item either increasing or decreasing the exposure on this side applies excepting one and that is the height of the exposure. It is only four stories high and the ten per cent reduction is made or .012, leaving .105. The exposure on the left is a fireproof building with a rate of $1.12 at a distance of ten feet. The exposure itself has more than seventy-five feet in length and the risk has sixty-five feet on that side. The initial charge is taken from the first table which is eighteen cents for one dollar. But as the rate of the exposure is $1.12, the additional amount over one dollar or twelve per cent must be added, making an initial charge of .202. No reduction applies except the five per cent reduction for length of side which is one cent, leaving nineteen cents which may be brought down to the bottom of the column. The exposure is now found to consist of the amount computed for three sides, namely: Right side .036, rear .105, left .19; a total of .331. The risk itself is more than five stories high and we must add to this charge fifteen per cent for each story over five or forty-five per cent, which is 14.9, which, added to the .331, makes a total exposure charge gross of forty-eight cents. Deducting the ten per cent, which is a working margin, leaves a net result of .432, and in computing rate the even cents are used, or forty-four cents.

This is a fair illustration and an actual example of the method of rating on the non-fireproof mercantile schedule.

SCHEDULE FOR FIREPROOF BUILDING

Early Rates for Fireproofing. The fireproof building while old in a certain sense, since early examples were erected one hundred years ago along somewhat modern lines, is nevertheless quite new from the standpoint of insurance rating. In the very beginning the tendency was to over-estimate this form of construction and it took many years before there was evolved a treatment of that type of construction which was at all satisfactory. The earliest attempts used the rate of a non-fireproof building and from that made a certain percentage deduction if the structure was fireproof. In certain cases that treatment is still followed and there are rules in force today which simply make this distinction between the fireproof and non-fireproof, namely: The property is rated as though it was of non-fireproof construction and then a deduction of a fixed percentage is made. It may be forty per cent for the contents and sixty per cent for the building.

The next advance was reached when the building began to be considered by floor units and different rates were made for each floor. This was but little more than the application of an ordinary schedule with a series of lessened charges according to the height of the floor and the general construction of the building.

There is some advantage in a non-burnable floor, although in other respects the building may be of inferior construction, especially in regard to the floor openings which have generally been the weakest point in connection with a fireproof building, the next being the lack of protection to the windows and the improper protection of the metal members. Experience in fires has called attention very sharply to these defects and so far as the protection to the metal members is concerned, that is now very well taken care of. Gains are also being made in regard to proper window protection. The floor openings are perhaps still unsatisfactory in many of these properties.

There are fireproof structures, as apartment houses, which have been rated by the old method of flat rating for a great many years. This is based on the idea that, as no distinction is made in rating a non-fireproof apartment house but one rate covers all for either the building or the contents, the same should be true of a fireproof apartment house which, even though it be larger and higher, has as an off-setting feature the superior construction. Such properties in certain parts of the country have been written at rates running from eight to ten cents, the difference between the two rates being merely a rough division for height which is taken at about ten stories. Properties under this height taking lower rate; above taking the higher rate.

Universal Rates. The mercantile schedule includes a distinct fireproof schedule which, like the non-fireproof, may never have been used exactly as it is given in the book, but yet very nearly so. Reproduction of one of these schedules which is in active use illustrates the plan.

	No.
KEY RATE (being Key rate 25c. less F. D. deductions) .10...............	
WALLS. 286—If skeleton construction, wrought-iron or steel columns or vertical supports (no charge for cast-iron), charge .02............	
287 Average thickness of two side or bearing walls (or either of them) less than twenty inches (obtained by adding thickness of various stories and dividing by the number), charge for EACH INCH of deficiency .01; if any portion of wall less than twelve inches, double the charge; (if built according to Building Law no charge)......................	
288 For each wall of stone or veneered with stone ashlar, plain, or "axed" finish, charge .02; if carved or ornamental .03...................	
UNPROTECTED IRON. 290—If columns and lower flanges of iron beams unprotected (halve charges for office buildings) as follows: for unprotected cast-iron columns .10; unprotected wrought-iron or steel columns .15; unprotected lower flanges of beams .02...... (N.B. Columns filled with cement dangerous.)	
AREA. 293—5,000 sq. ft. to 10,000, each 1,000 in excess of 5,000, ½ of .01	
294 If over 10,000 sq. ft. each 1,000 in excess of 10,000, .02............. (Not exceeding a total of .50.) (If building occupied exclusively above grade floor for offices* or dwellings, no charge for area.) (NOTE.—If mercantile building exceeds twelve stories, double area charge.)	
294a Wood partitions or plaster on wood studs and laths .05............	
HEIGHT. 295—(.....Stories). For each story over eight up to twelve, charge .01..	
296 Twelfth story and each story over twelve up to fifteen .03..........	
Amount carried forward	

No.

Amount brought forward ....

297 Fifteenth and each story over fifteen, charge .10....................
(Office buildings* charge one-fourth height charges.)

297a If merchandise stored above the seventh floor, charge 10 cents, and add 2 cents more for each floor above seventh up to tenth, and 5 cents more for tenth and each floor above tenth. For example, an eleven story building would have 24 cents added. No charge for sample stocks and only one-half charge for stocks whose first column charge is less than 10 cents.

FLOORS. 298—Wood floor boards laid solid on concrete without air space .05, if with air space .10, (office buildings* one-half)........

FLOOR ARCHES. 298a—If concrete, cement or approved plaster composition floor arches with iron centers or supports (such as Metropolitan, Roebling, Expanded Metal, Fawcett, Columbian, Bailey, Guastavino) (no charge for segmental arches of brick or burnt clay or terra cotta) .04..

If on exposed corrugated iron centers .05. If flat arch supported on iron (such as Rapp's flat type) .08. If space between iron floor beams exceeds 5 feet, for each foot in excess .01................

N.B. One-half these charges in office or hotel buildings.

ELEVATOR. 299—Not cut off according to standard, but in hallway or enclosed court, etc., .03 (Office or hotel building, charge .01)......

300 Open, .05 (office building, charge .02)............................

301 Enclosed in wood and glass, .10 (one-half charge for office building)...

(Note—If elevator and stairway in one shaft or opening, one charge for the two. For each additional elevator not cut off add .01.)

STAIRWAYS. 302—Not cut off except by wood lath and plaster hallway, etc., .05...

303 If enclosed in wood and glass, .10 (one-half charge in office or hotel building)...

304 Open, charge ½ cent each floor not exceeding a total of .07 in mercantile building and .02 in office or hotel building..................
(One-half charge for 302, 303 or 304 if charge has been made for 299, 300, or 301.) For additional stairway no charge.

Stairway and elevator same shaft or opening, one charge for the two.

305 If at least one stairway is not fire-proof with metal treads under slate or marble treads (which will yield to fire), charge as many times .02 as the building has floors (one-third charge for office building). If stairway in fire-proof hall or enclosure protecting stone treads from heat one-half final charge.

WELLHOLES, ETC. 306—Open, for each floor pierced, .03........
(Half charge for office building.).............................

WOOD CHUTES, VENTILATING SHAFTS, DUMB-WAITERS, INTERIOR COURTS, CHANNELS FOR PIPING OR ELECTRIC WIRES, ETC., 307—Each floor pierced, one cent.

Note.—No charge need be made for openings for steam and water pipes if the space around the pipes is filled in with mineral wool, asbestos, or other incombustible material, or otherwise arranged to prevent draughts and prevent leakage of water to floor below.

SKYLIGHTS. 308—Exceeding nine square feet, for each nine square feet (not exceeding total of 10), .01.................................

309 If covered with strong wire netting, one-half charge...............

STREET. 310—If street on which building fronts is less than sixty feet wide but over fifty (unless opposite side vacant), .01............

311 If under fifty feet, for each five feet under fifty, .01................

NUMBER OF TENANTS 313—Each in excess of one, exclusive of office and dwelling tenants, ¼ cent...................................

MANUFACTURING RISKS, 313a—Charge .01 for every 20 operatives employed in excess of 20 not exceeding a total of 10 cents where first column charge does not exceed 25 cents, and double this amount for those tenants whose first column charge exceeds 25 cents, but not exceeding a total of .25.........................

STONE Piers, stone columns, pillars, or brick piers with bond stones or cap stones, 315—carrying important weights, especially if supporting beams or girders in basements, cellars, etc., charge according to number, not less than .02.............................

Total...............................

EXCEPTIONAL CONSTRUCTION—For fireproof floor surfaces of cement concrete or asphalt deduct 5 per cent...................

If floors inclined for carrying off water with scuppers 2 per cent...

METAL TRIM THROUGHOUT, deduct 5 per cent...................

320 RESULT CARRIED FORWARD...........................

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*Office buildings include partial occupancy by sample stocks or small restaurants or grade floor stocks whose first column charge is less than 15 percent.

FIRE-PROOF SCHEDULE—BUILDING

320 RESULT BROUGHT FORWARD....................................

Add for occupancy—(25 per cent amount in first column of table, selecting charge for most hazardous occupancy). Increase charge 5 per cent of its amount for each story on which most hazardous occupancy is located above second. No...

322 RESULT...

DEDUCTIONS FOR FIRE APPLIANCES, ETC., ON BUILDINGS	No.	%	Cts.
343 Auto. fire alarm to central station 10 per cent to 10 cents.....			
344 Standpipe, near stair landings with external Siamese street connections for use of fire dept., 5 per cent................			
345 Standpipe, internal with tank supply, 1 per cent.............			
347 Automatic sprinklers in basement, 3 per cent (no deduction if allowance has been made for sprinklers throughout building)...			
348 If building occupied exclusively for offices or dwelling, or both, 20 per cent...			
349 If occupied exclusively for offices or dwellings, or both, above grade floor, 10 per cent................................			
350 Roof hydrants, 1 per cent..................................			
352 Watchman with clock, 2½ per cent to 2½ cents................. Special Building Signal 5 per cent to 5 cents............... Without watchman and clock 2½ per cent to 2½ cents........			
353 Auxiliary Private Fire Plant, Force Pump, etc., available for day, night, and holidays; standpipe, hose attached at each floor; competent engineer on hand at all times, deduct 10 per cent. (This in addition to 344, 345 and 352)..........			
354 FIREBOAT. If risk within 800 feet of Fire Boat, 5 per cent..			
355 Casks of water or sand or filled pails (two filled pails to each 1,000 sq. feet of floor area), 5 per cent.................... NOTE—(Approved Extinguishers accepted in lieu of half required number of pails.)			
TOTAL DEDUCTIONS..............		%	& c.

RESULT. Rate on building occupied, unexposed......................

323 EXPOSURE...

324 RESULT. Rate on building, occupied and exposed...................

324a SPRINKLERS. If according to requirements of the Fire Underwriters deduct......%...

325 COINSURANCE with..........% rate..............................

ADD FOR FAULTS OF MANAGEMENT IF ANY	No.	Chge.
380 If bottom of elevator shaft used for oil, coat, or other closets, .10...		
381 Swinging or other unsafe gas brackets or bracket lamps, within 36 inches of combustible ceilings, etc., for one, .05; for each additional, .01..		
382 Untidiness, rubbish, ashes, etc., especially in cellar .10........		
383 Empty boxes rear yard, alleys, etc., .02.....................		
384 Lights in show-windows, open, unprotected, .05..............		
385 Sawdust spittoons or sawdust on floors, .05..................		
386 Kerosene used to sprinkle floors, .10.......................		
387 Ash and waste cans not metal, .10..........................		
388 Electric light system and installation not in compliance with underwriters' rules, or arc lights unprotected, .25.........		
389 Crowded Mdse. without proper aisles opposite or too near windows, not less than .05..................................		
Sign on roof to interfere with Fire Department..............		
Communications until approved...........................		
Unsafe Electrical Apparatus.............................		
Unsafe Heating Apparatus................................		
....		
....		
....		

FINAL RATE OF BUILDING

MINIMUM RATE.—No office building to be rated below .05 or mercantile building below .10 after all deductions including coinsurance have been made.

TO OBTAIN RATE ON STOCK IN FIRE-PROOF BUILDING

....

....

RATE OF BUILDING at No. 320..................

Add 75 per cent rate named in second column of occupancy table..............................

Add 25 per cent the amount named in the first column for the stock to be rated......................

Add, in case there be any other occupancy of building which increases the rate of the building by a greater amount named for the first column of the occupancy table than the risk to be rated, *one-quarter* the difference between such higher figure and that named for the risk.....................

If the higher rated or excess hazard be separated from the stock to be rated by fireproof partitions or floors, deduct 10 per cent of the excess charge for each separating fireproof floor or partition, not exceeding seventy per cent in all, of such excess.

IF MERCHANDISE IS STORED ABOVE THE SEVENTH FLOOR, add to the rate of *each stock* in the building, *no matter on what floor located*, as many times 1 cent as the building has stories in height. (For example, in a 10-story building occupied throughout for mercantile purposes, 10 cents would be added; in an 11-story building, 11 cents, etc.)

Merchandise should not be stored at a greater height from the street grade than 85 feet, even with the best fire department. At that height it is liable to wreck the building and affect every stock in the building, as well as the building itself, see Note 297.

STOCKS ABOVE OR BELOW GRADE FLOORS.—Charge as many times 5 cents as the floor on which stock is located is stories above the fourth or below the grade. If distributed over two or more floors for same assured, and with 80 per cent coins., and cut off each story, three-fourths of average charge.

For example, merchandise on the fifth floor should pay 5 cents; on the sixth floor, 10 cents; seventh floor, 15 cents; on all 30 cents, average 10 cents, three-fourths of which, 7½ cents (if cut off each story), is the proper charge for same stock covering these three floors.

Grade Floor Stocks.—Deduct for stock entirely on grade floor, 20 per cent; if on second deduct 10 per cent; if on grade and second deduct 10 per cent; if on basement and first 5 per cent.

Floor Basement.	**Floor**........
Stock........	**Stock**........
Class No.....	**Class No**.....

DEDUCTIONS FOR FIRE APPLIANCES, ETC., ON STOCKS.

No.	%	cts.

361 If merchandise covered by tarpaulin covers, each night, 5 per cent..........................

362 Proximity to fire department station, hose or hook and ladder house, if risk within 300 feet, 2 per cent; if next door or on opposite side of street, 5 per cent...

363 Basement and sub-cellar sprinklers, if goods on skids, 2 per cent......

364 Automatic sprinklers in basement (no deduction if allowance has been made for sprinklers throughout building), 10 per cent.......

365 Casks of water or sand or filled pails (2 filled pails for each 1,000 square feet floor area), 5 per cent.......

Note—(Approved Extinguishers accepted in lieu of half required number of pails.).............

266 Merchandise in tin-covered cases, 5 per cent......................

367 If building occupied entirely above grade floor for offices, 5 per cent..

Amount carried forward.....

		No.	%	cts.	Floor Basement. Stock........ Class No.....		Floor........ Stock........ Class No.....	
	Amount brought forward....							
368	If building occupied entirely for office and dwelling, 10 per cent...							
370	Watchman with watch-clock 2½ per cent to 2½ cents................ Special Building Signal 5 per cent to 5 cents.................... Without watchman and clock 2½ per cent to 2½ cents.............							
371	Standpipe, internal, near stairs with tank supply, 1 per cent.........							
372	Standpipe, with external Siamese connection at street for use of fire department, 5 per cent.........							
373	If one or more chemical engines on wheels, 3 per cent..............							
374	Auto. fire alarm to central station 10 per cent to 10 cents..........							
375	SKIDS. If Merchandise in bales or unopened cases or similar original and unbroken packages is kept on skids or platforms 6 inches high, deduct 2 per cent....							
377	Floors arranged for carrying off water with scuppers, 5 per cent..							
378	FIREBOAT. If risk within 800 feet of Fire Boat, 5 per cent.....							
	TOTAL DEDUCTIONS.......		% & c.					
	RESULT—Rate on stock unexposed....................							
	EXPOSURE....................................							
329	RESULT—RATE ON STOCK EXPOSED....... SPRINKLERS deduct same as 324a............							
330	DEDUCT FOR COINSURANCE, if policy covers only one floor, or more than one but not cut off at each story ¼ of 1 per cent for each 1 per cent of coinsurance in excess of 20 per cent of value (15 per cent for 80 per cent). If policy covers two floors cut off at each story, 20 per cent; three floors cut off each story, 25 per cent; four or more cut off at each story, 30 per cent for 80 per cent.							
331	RESULT—Rate on stock with 80 per cent coinsurance.................................. ADD FOR FAULTS OF MANAGEMENT, IF ANY....							
	FINAL RATE ON STOCK. MINIMUM RATE—No stock to be rated below 15 cents after all deductions including coinsurance have been made.							

DISCUSSION OF BUILDING CHARGE AND DEDUCTIONS

There are but few points in the schedule which will require special consideration, because the general principles of schedule rating have been fairly fully covered in the consideration given to the non-fireproof schedule.

Key Rate. The key rate in any given town or city would be the same whether the structure were of fireproof or any other type.

Skeleton Structures. Item 286 on the schedule shows that a charge is made for this type of construction. This is a modern fireproof building type. When the schedule was evolved many years ago there was a general impression that these metal members would not wear well, but would be subject to certain peculiar kinds of damage and deterioration. In the lapse of time one or two of these fireproof buildings have been torn down, notably an eleven-story building at the northwest corner of Wall and Nassau streets in New York City. It showed that the skeleton frame was practically perfect and the building had been erected fifteen years, so it is extremely doubtful, if the schedule were revised today, whether the charge would be included or not; in all probability it would not.

Unprotected Iron. It has taken many years of education to bring the builders and owners to the point where the proper protection of metal members is appreciated. The result, however, has been gradually brought about and it would be a peculiar case today where such a structure could be erected and the metal members not adequately protected from damage by fire. The phrase fireproof has proved to be rather deceptive to many as covering almost any type of construction that was a little better than non-fireproof. There is no magic in the word fireproof and the careless or defective construction of such properties simply means an increased loss at the time of the fire.

Area. Twice as many square feet are permitted in this type of structure as in the non-fireproof before charges are imposed, and even up to a total area of ten thousand square feet the charge is very slight; beyond that point it increases rapidly, having the stop point which is necessary and also having an additional note that if the building be over twelve stories high double the charge must be made. There is one other interesting practice in regard to the area of the fireproof building and that is where it is occupied for offices or dwellings no charge is made. It is based on the fact that buildings of that type of occupancy are supposed to be divided into small areas with a fair prospect of a fire being confined to one room.

Height. Under item 297*a* there will be noted that a certain charge is made if merchandise is stored above the seventh floor. This is quite a heavy charge and is founded on a desire to keep stocks below the eighth floor and also the belief that presence of stocks on the upper floors would tend to wreck the building during a fire. The first reason, when the property is unsprinklered, is certainly excellent, since the difficulty of fighting a fire in such a building beyond the height noted is enormous. In fact, there is no way for the firemen to get hold, but it must burn itself out, which was what happened when the Parker Building fire occurred in New York City. This was a twelve-story building unsprinklered, with poor floor openings, stocks on every floor. The fire took possession, so to speak, of the property and burned until it exhausted itself. The firemen were not able to do more than protect, to a certain extent, surrounding property.

Floors. This point in the schedule brings out an interesting fact in connection with the old method of construction. The girders were and are rather deep and there was left a very large space between the under side of the floor boards and the top of the arch. This charge was placed in the schedule purposely to bring about the filling up of this space so that the floor boards would lay solid on concrete. A distinct advance has been made, even in this method, and buildings are being erected which are comfortable and yet have the solid concrete floors without wood surface.

Floor Arches. The distinction made between the brick or terra cotta arch and concrete, like item 286, would probably not be made today. Far more is known about concrete than was known fifteen years ago and the competition between the two types of construction has perhaps brought the efficiency of each to practically the same point so far as insurance is concerned. It was sound practice which placed as the standard the brick or terra cotta segmental type of arch. The segmental form has practically passed away and the flat arch has taken its place. That is another good reason why no distinction would be made today between the two types.

Width of Streets. The charges for this condition are based on the difficulty of fighting fire in a high building which fronts on a very narrow street.

Exceptional Construction. For exceptional construction such as the absence of wood floor boards an allowance is then made. It will be noted that the persons who erect the structure gain doubly by omitting the wooden floor boards. No charge would be made under item 298 and there would be the credit at the bottom. Deduction is also made if metal trim is used throughout the building. This means that the finish, base boards, and all other parts are covered with metal. That is being done to a slight extent. There are a few properties which have been built according to these items and are receiving the allowance therefor.

Final Rate. The first column charge as it would affect the building does not differ from that in the non-fireproof. The deductions for fire appliances are practically the same with the possible exceptions that the standpipe is treated on a somewhat higher basis, and furthermore under item 353 a substantial allowance is made for an auxiliary private fire plant. After the deductions are made the exposure is added and then any reduction due for sprinklers and finally the reduction for coinsurance. Then come faults of management. A stop rate is fixed, below which the rate of insurance does not fall. It is possible to erect fireproof buildings of seven stories in height and by following the schedule as a standard to so avoid charges that the minimum rate of five cents is reached in an office building and ten cents in a mercantile property.

CONTENTS RATE

Stock Above Seventh Floor. The various charges provided for in computing the rate of the contents do not call for any special elucidation, as they have been quite fully treated under the non-fireproof. The exception to this statement is perhaps found in the charges which are made for the height of stocks. Thus, if merchandise is stored above the seventh floor each stock in the building, no matter on which floor rated, is subject to a charge of one cent for each floor that the building is stories in height. The schedule is very severe against placing stocks above the seventh floor and bears down upon them very severely for infractions of this rule; experience, however, has demonstrated that such severity is only just.

A fire occurred in an office located on the twenty-sixth floor of the Singer tower. The construction of the tower is such that the fire was confined to the room in which it started, but it completely destroyed the contents of that room. A fireproof building will act, and the better its construction the better it will act, like a furnace; it holds the property within itself as a furnace holds fuel within its body and permits it to burn. It is less susceptible to exposure fires probably, but it is a serious question as to whether even this point which has run in favor of the fireproof buildings is not rather due to the fact that there have not been enough of such structures in the country to furnish the law of average.

Charges and Deductions. The deductions for various appliances follow, then the exposure, the sprinklers, the coinsurance, the charges of the faults of management, if any, added and the stop rate fixed. In regard to the faults of management it must be pointed out that while in a non-fireproof building they are charged against every tenant and against the building, in a fireproof building certain minor defects, as excess benzine, unsafe gas brackets, are charged against the individual tenant on whose floor they exist. This is in accordance with the now accepted principle of treating a separate floor or floors of a fireproof building as distinct units and making the charges apply to the individual floor. The defect, of course, may be so serious, as in the case of steam pipes which run through the building, that the charge may be made in the building rate and that of every tenant in the building.

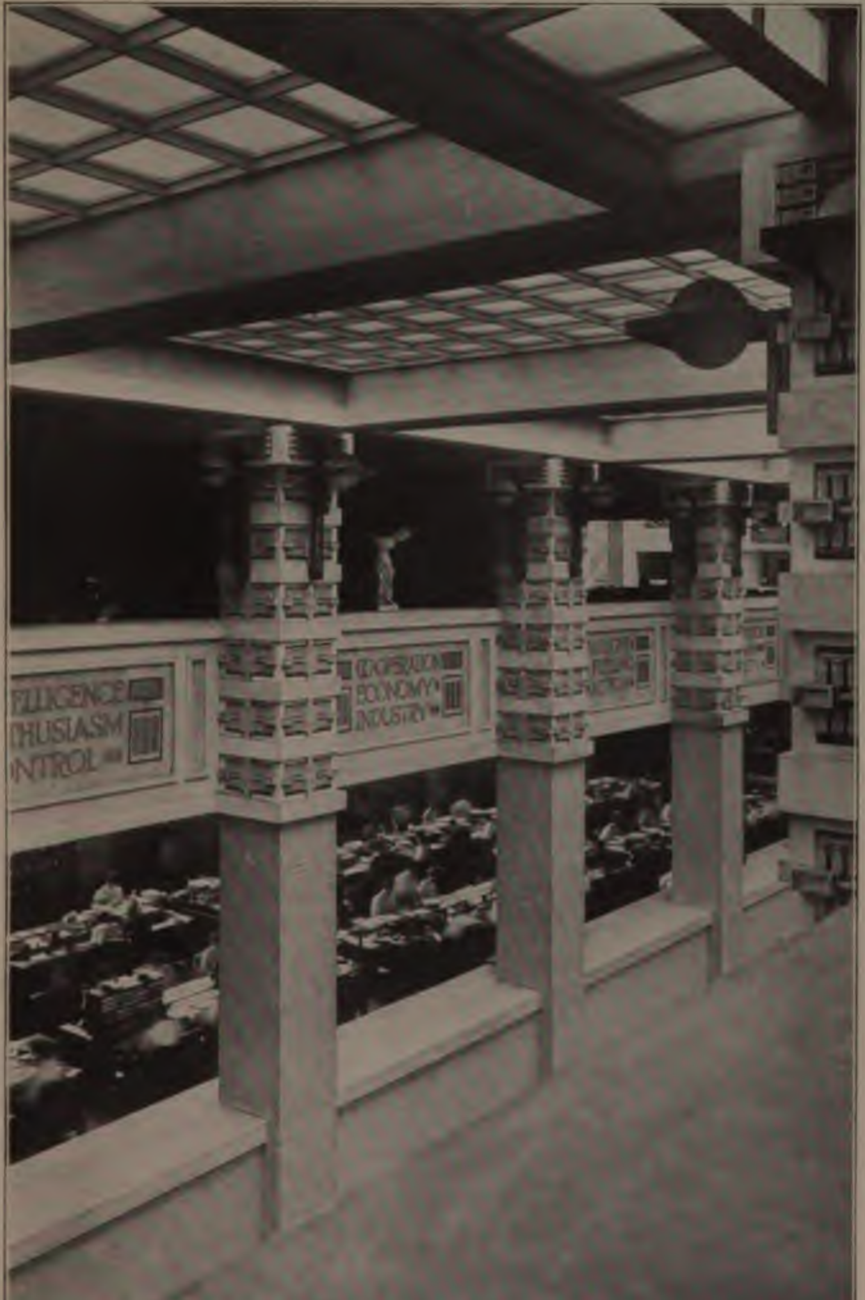
Coinsurance. Coinsurance in connection with the rating of fireproof properties calls for different treatment, and it calls for quite different treatment in regard to the building as against the contents.

The general statement may be safely made that so far as stocks are concerned in a fireproof building there is but little if any advantage over a non-fireproof. They may fare somewhat better in the case of an exposure fire, but once the fire has secured a foothold, a stock would burn even more readily than it would in a non-fireproof building. In the case of the building, however, the superior construction will resist fire, even a very severe one, and come through it in a fairly good condition. In the illustration showing the damage to the piers in the Cammeyer fire a loss on contents in the building was about a half million dollars. The loss to the building was about thirty thousand dollars, or a rather small percentage of the building value; but in the case of the contents, practically a total loss. In the Parker Building fire, on which the insurance loss was the largest that ever occurred in a single property in the history of fire insurance in the western hemisphere, the loss on contents, amounting up to a million and a half, was practically total, and while the loss on the building was large it was only about sixty per cent of the value of the building. The structure was twelve stories high. The fire raged very severely for over twelve hours and in due time burned itself out. In spite of this severe punishment which the building received, it still brought forty per cent of its value through as salvage. The same lesson has been taught by small fires where the entire contents of a floor may be destroyed and the damage to the building be very slight, so there no longer exists any doubt and did not when the schedule was produced, but what there should be a sharp difference between the coinsurance allowance on the contents and building.

On Contents. In the case of the contents the allowance for coinsurance is based on the fact that the first twenty per cent of insurance is of no value; the loss will generally be total up to that point any way and it is only when the insurance is carried beyond that point that the underwriter can afford to make an allowance. One-fourth of one per cent is made for each one per cent of additional insurance beyond twenty. Hence, for eighty per cent coinsurance fifteen per cent allowance is made where the stock covers on one floor, or where it covers on more than one floor and the floor openings are not protected in any other manner, or in a very poor manner. If the floor openings have protection which is of some value, then a larger allowance for coinsurance is made.

On Building. The allowance for coinsurance on a building is based on the following principle: It was concluded from fairly reliable statistics that fifteen per cent of the value of the building would cover the damage that could very easily be done, such as damage to wood trim, window and door frames, floor boards, paint and fresco work, plate glass, etc.; all of these, of course, are as destructible in a fireproof as in a non-fireproof. It was decided that if insurance only to fifteen per cent of the value was carried there was no benefit to the underwriter over against a building of non-fireproof construction because the parts which he would be insuring were as easily damaged as though they were in a non-fireproof building. At the other extreme, of course, was one hundred per cent or full insurance.

A building supposed to be worth a million dollars was taken and an estimate made as to the rate of insurance for each one hundred thousand dollars carried. The assumed rate for the first fifteen per cent was 1 per cent which would have yielded a premium for one hundred and fifty thousand dollars of insurance of fifteen hundred dollars. Now it followed that if, after the easily destructible parts of the building were taken care of by insurance, the owner



INTERIOR OF FIREPROOF OFFICE BUILDING

THE NEW YORK
PUBLIC LIBRARY

ASTOR, LENOX AND
TILDEN FOUNDATIONS

TABLE III

Coinsurance Data

Percentage Insured	Percentage of Preceding Rate Charged for Next $100,000 of Insurance	Amount Insured	Rate	Premium
15%	100%	$ 150,000	100 cents	$1,500
20%	45%	200,000	86.3 "	1,725
30%	40%	300,000	69 "	2,070
40%	35%	400,000	57.8 "	2,312
50%	30%	500,000	49.7 "	2,485
60%	25%	600,000	43.5 "	2,610
70%	20%	700,000	38.5 "	2,695
75%	17.5%	750,000	36.4 "	2,732
80%	15%	800,000	34.4 "	2,710
90%	10%	900,000	30.9 "	2,785
100%	5%	1,000,000	28 "	2,800

chose to pass on and make provision for the other parts, the additional insurance could be carried at a much lower rate than the first one hundred and fifty thousand dollars. If two hundred thousand dollars was carried the additional fifty thousand dollars beyond one hundred and fifty thousand could be taken at a much less rate than the first sum. In brief, all the insurance carried beyond the first one hundred and fifty thousand dollars was assumed to be what is termed excess insurance which would not be called upon for a loss until the first insurance was exhausted. The third one hundred thousand dollars it was assumed could be safely carried at a forty per cent less rate than the first two hundred thousand dollars and for each one hundred thousand dollars beyond that an increasing allowance of five per cent was made in the rate. This data is set forth in Table III.

For different rates of insurance from 15 cents up to $1 and coinsurance from 20 to 100 per cent, consult the tabular matter on the following page.

ILLUSTRATIVE EXAMPLE

As an illustration of the method of rating a fireproof building on the schedule which is being discussed, the following, taken, as was the non-fireproof example, from an actual building, is worthy of study:

RATE No. 324 of Universal Schedule*	PERCENTAGE OF INSURANCE TO VALUE									
	20%	30%	40%	50%	60%	70%	75%	80%	90%	100%
	cents	cents	cents	cents	cents	cents	cents	cents	cents	cents
15 cts.	12.95	10.35	8.67	7.45	6.52	5.77	5.46	5.16	4.63	4.20
16 "	13.81	11.04	9.24	7.95	6.96	6.16	5.82	5.50	4.94	4.48
17 "	14.67	11.73	9.82	8.44	7.39	6.54	6.18	5.84	5.25	4.76
18 "	15.53	12.42	10.40	8.94	7.83	6.93	6.55	6.19	5.56	5.04
19 "	16.39	13.11	10.98	9.44	8.26	7.31	6.91	6.53	5.87	5.32
20 "	17.26	13.80	11.56	9.94	8.70	7.70	7.28	6.88	6.18	5.60
21 "	18.12	14.49	12.13	10.43	9.13	8.08	7.64	7.22	6.48	5.88
22 "	18.98	15.18	12.71	10.93	9.57	8.47	8.00	7.56	6.79	6.16
23 "	19.84	15.87	13.29	11.43	10.00	8.85	8.37	7.91	7.10	6.44
24 "	20.71	16.56	13.87	11.92	10.44	9.24	8.73	8.25	7.41	6.72
25 "	21.57	17.25	14.45	12.42	10.87	9.62	9.10	8.60	7.72	7.00
26 "	22.43	17.94	15.02	12.92	11.31	10.01	9.46	8.94	8.03	7.28
27 "	23.30	18.63	15.60	13.41	11.74	10.39	9.82	9.28	8.34	7.56
28 "	24.16	19.32	16.18	13.91	12.18	10.78	10.19	9.63	8.65	7.84
29 "	25.02	20.01	16.76	14.41	12.61	11.16	10.55	9.97	8.96	8.12
30 "	25.89	20.70	17.34	14.91	13.05	11.55	10.92	10.32	9.27	8.40
35 "	30.20	24.15	20.23	17.39	15.22	13.47	12.74	12.04	10.81	9.80
40 "	34.52	27.60	23.12	19.88	17.40	15.40	14.56	13.76	12.36	11.20
45 "	38.83	31.05	26.01	22.36	19.57	17.32	16.38	15.48	13.90	12.60
50 "	43.15	34.50	28.90	24.85	21.75	19.25	18.20	17.20	15.45	14.00
55 "	47.46	37.95	31.79	27.33	23.92	21.17	20.02	18.92	16.99	15.40
60 "	51.78	41.40	34.68	29.82	26.10	23.10	21.84	20.64	18.54	16.80
65 "	56.09	44.85	37.57	32.30	28.27	25.02	23.66	22.36	20.08	18.20
70 "	60.41	48.30	40.46	34.79	30.45	26.95	25.48	24.08	21.63	19.60
75 "	64.71	51.75	43.35	37.26	32.61	28.86	27.30	25.80	23.17	21.00
80 "	69.04	55.20	46.24	39.76	34.80	30.80	29.12	27.52	24.72	22.40
85 "	73.35	58.65	49.13	42.24	36.97	32.72	30.94	29.24	26.26	23.80
90 "	77.67	62.10	52.02	44.73	39.15	34.65	32.76	30.96	27.81	25.20
95 "	81.98	65.55	54.91	47.21	41.32	36.57	34.58	32.68	29.35	26.60
100 "	86.30	69.00	57.80	49.70	43.50	38.50	36.40	34 40	30 90	28.00

*For any intermediate rate combine two of above; for example, the rate of 31 cents would be that for 15 cents and 16 added; the rate for 32 would be double that for 16.

For example, if the rate be 80 cents and the percentage of insurance carried (percentage coinsurance clause in the policy) is 50% the rate will be 50% of 80 or 39.76 cents. If the rate at No. 324 be 50 cents, for 60% coinsurance the rate would be 44% of 50 cents, or 21.75 cents, etc., etc.

Building Rate. *Key Rate.* The key rate charged is 10 cents.

Unprotected Iron Work. The report states that the iron interior columns are entirely unprotected, charge 10 cents.

Area. The building covers ten thousand five hundred square feet. Five thousand square feet are permitted without charge and for each thousand in excess of that up to and including five thousand a charge of one-fourth of a cent is made. This would thus make one cent for four thousand and one-fourth of a cent for the fifth thousand or one cent and three mills under item 293. But the building exceeds ten thousand square feet, having five thousand over, so there would be a charge of one cent under item 294.

Height. The property is nine stories high and for the one story over eight the charge is one cent.

Merchandise Above the Seventh Floor. Merchandise is stored on each floor, hence, under 297*a* there would be a charge of ten cents and two cents for the eighth floor and two cents for the ninth floor; total charge of fourteen cents.

Floors. There are wooden floor boards with an air space beneath them; hence, the maximum charge of ten cents is due. The report furnishes the information that the floor arches are of terra cotta, so for the arch itself no charge will be made, but the arches have a span of six feet, which is one foot in excess of five, and the charge will be one cent.

Floor Openings. Elevators are in a hallway of fireproof construction but the doors are defective. The proper charge is three cents under item 299. There is an additional elevator from basement to first—open—and the charge should be made under item 300. It must be prorated; as it only pierces one floor where eight floors might be pierced, the charge is one-eighth of six cents or seven mills.

Stairways. The main flight adjoins the elevator. A charge cannot be made, but there is an additional stairway—open—from basement to first, and for this a charge may be made under item 304. This naturally would be, according to the reading of the item, one-half of a cent, but additional stairways are subject to one-half charge. Therefore, in place of the charge being one-half cent, it is one-half of the sum of three mills.

Non-Fireproof Treads. The importance of having the stone treads supported by metal beneath is something which was only learned by experience in actual fires. The slate or stone yields readily to a fire if it is not backed up with a metal member. The result is that with the elevators out of commission and the stairways unreliable so that the firemen may not use them there is no means of ascending to upper floors or descending from them. The schedule provides a somewhat heavy charge where the treads under one stairway at least, if there be more than one stairway, are not properly protected. In this case the stairway runs from the basement to the roof piercing nine floors and one cent is charged for each floor or nine cents.

This charge very well illustrates the elasticity of the schedule, since there have been actual cases where, while this defect existed in the building, excellent fire escapes have been placed on the outside of the property. When this was done an additional allowance was granted under this item. It was made one-half instead of the full charge. This consideration was based on the fact that the fire escape mitigated to a certain extent the defective condition of the stairway.

Number of Tenants. The report of the inspector shows that there are sixteen tenants in the building exclusive of office tenants. One such tenant is permitted without charge; hence, there are fifteen to be charged for or a total amount of three cents and eight mills.

Number of Hands. There are eighty-six hands employed in various kinds of work in the building. This always means hands engaged in manufacturing and not those who are buying and selling or merely caring for the property. Twenty are permitted without a charge, leaving sixty-six to be charged for. It is one cent for each twenty in excess of twenty; hence, a three cent charge for sixty hands, the remaining six make a charge of three mills, as the charge is one mill for two hands, a total charge of three cents and three mills. This completes the schedule down to the first addition and shows a total of .684, which amount is carried forward at point 320.

Occupancy Charge. The charge for the most hazardous occupancy which is now to be made under item 320*a* proves to be a first-column charge of twenty-five cents located on the ninth floor. One-fourth of this charge is used in the territory where this risk is located and this six and one-fourth cents is subject under the schedule to an increase of five per cent for each floor above the second or thirty-five per cent in all, thus making the full charge .085. The next total will be .769. No allowances were in order at the time the rate was computed and the exposure charge was twenty-eight cents which added to the .769 makes a total of 1.049.

Coinsurance. This will be subject to reduction for coinsurance; eighty per cent coinsurance is carried. By turning to 'the table printed on page 90 it may be noticed that where the rate of insurance is one dollar the proper amount to be taken under eighty per cent coinsurance is 34.4 per cent, and by taking this percentage of the rate 1.049 it gives .361 as the rate on this building with a coinsurance allowance.

Final Building Rate. A recapitulation of the building rate will present the matter clearly to view.

Key rate		.10
Unprotected iron work	Item 290	.10
Area	" 293	.013
Area	" 294	.01
Height	" 295	.01
Merchandise above seventh floor	" 297*a*	.14
Floors	" 298	.10
Width of arch	" 298*b*	.01
Elevators	" 299	.03
Additional elevators	" 300	.007
Stairways	" 304	.003
Lack of metal under treads	" 305	.09
Number of tenants	" 313	.038
Number of hands	" 313*a*	.033
Total		.684
Hazard charge	Item 320*a*	.085
Second total		.769
Add exposure	Item 323	.28
Third total		1.049

To make the proper reduction for eighty per cent coinsurance proposed on the building, 34.4 per cent of 1.049 is taken which amounts to .361.

Contents Rate. *Exposure.* The computation of the exposure for fireproof building does not differ until the point is reached where the exposure charge is added together at the bottom of the heavy black line. Here again the principle of a stop charge is necessary. The statement that, if the property is over five stories high fifteen per cent must be added for each story, would make a prohibitive charge when buildings now run up to twenty, thirty, forty, and fifty stories high. This charge is, therefore, limited to five stories or seventy-five per cent regardless of the height of the building.

In the case of the present exposure the table gives a total amount of .198. Adding the seventy-five per cent for the height and another total is reached of .317; deducting from this the ten per cent for working margin and it leaves twenty-eight cents to be added to the building. Under normal conditions the contents of a fireproof building are not subject to as heavy a charge as the building. This is due to the fact that the building must first get the blow of the fire and may resist it for some time before it will break into the building and damage the stocks; hence, for working purposes the full charge of twenty-eight cents would be made against the building, while against the contents one-fourth of this sum would be deducted, leaving a charge of twenty-one cents to be made against the contents. It has also been learned by experience that the upper floors are more susceptible to damage from an exposure fire than the lower floors. Therefore, if there were a tenant occupying the basement and first a full exposure charge of twenty-one cents against the contents would not be made against the tenant on the lower floor but about one-half that allowance or .105. As the mills are seldom considered in exposure charges a ten cent charge would be made.

Occupancy. The principal tenant in this building occupied all of the building with the exception of part of the basement and first floor. The occupancy of the basement was for the usual housekeeping purposes, as it may be termed, the power and electric light plant. In addition one cylinder press and a series of vaults for the storage of electrotype plates. The first was retail books; the second offices and retail books; third, offices and chapel, while the fourth and fifth were offices, the seventh and eighth offices and storage of printed sheets and the ninth a bindery. The classification fell under a twenty-five cent first column charge and seventy-five cent second. The key rate for the contents of the fireproof building is the sum reached on the first page of the schedule or the first total as it has been termed which in this case is .684. Three-fourths of the second column charge is then taken or .563, one-fourth of the first column charge or .063. As there are stocks above the seventh floor one cent is added for each floor in the building; a total of nine cents. The final charge before making the first total on contents is for the stock above the fourth floor and below the first floor. Stocks situated in the basement take a charge of five cents. No charge is made for height until the fifth floor is reached when the charge is five cents for the fifth floor, ten cents for the sixth and fifteen cents for the seventh, twenty for the eighth and twenty-five cents for the ninth; a total charge of eighty cents. But in this case the charge of eighty cents is not made, but as the stock is spread over ten different floors, basement to ninth, inclusive, the chance of a loss being confined to one floor is fairly good, so the average charge is made; in other words, this full amount is divided by the number of floors over which the stock is spread. It is ten floors, therefore, the charge is eight cents. The total at this point $1.48. No allowances are due at this time and the exposure charge may be added direct to this amount. It was decided to be twenty-one cents on the contents, hence, the second contents total is $1.69. The deduction for coinsurance is fifteen per cent, as the openings to the stairways and elevators do not warrant any larger allowance. Fifteen per cent is .253 which, deducted from $1.69, leaves a rate of 1.437. Concerning the allowance for coinsurance on the contents it will be appreciated that the more perfectly the floors in the fireproof building are separated, the one from the other, the greater chance there is of confining the loss to any one floor when a fire starts. Hence, a graded allowance, based on the number of floors covered and the character of the cut-offs and floor openings is provided for. This graded allowance is as follows:

In order to entitle a stock to the deductions above 15 per cent for coinsurance for floors cut off at each story, the enclosure must be of fireproof material and have self-closing doors. If with heavy wood doors and heavy glass sashes, increase the 15 per cent allowance one-third of the difference between 15 per cent and the maximum credit for standard cut-offs to which stock might be entitled according to the number of floors upon which it is located. If the doors be metal-covered or kalameined, but are not thoroughly standard, or have wood sills, or do not fit openings closely, increase the 15 per cent allowance two-thirds of the difference.

Following deductions to be made for 80% coinsurance clause.

Stock Distributed over	Wood doors	Non-Standard fire doors	Standard doors
2 floors	16⅔%	18⅓%	20%
3 "	18⅓%	21⅔%	25%
4 " or more	20%	25%	30%

Final Contents Rate. A recapitulation of the contents rate reads:

Key rate	.684
Three-quarter second column charge	.563
One-quarter first column charge	.063
Height charge	.09
Distribution over floor charge	.08
Total carried forward	1.48

Amount brought forward	**1.48**
Add exposure charge	**.21**
Total	**1.69**
Deduct coinsurance fifteen per cent	**.253**
	1.437

In connection with the charges taken for occupancy both the charge for ignibility and combustibility are the first and second column charges as they are commonly termed. It may not have been made clear as to why a fractional part of these charges are taken. In the list of occupancy charges as furnished in the schedule, these charges are given for the gross amount and the percentage of these charges is taken, where the whole is not used, for a given locality, when the schedule is adapted to meet the conditions of that locality. In the example used the fractional parts taken for the place have been given, it being deemed better to furnish a real live example than one based on theoretical conditions.

GRADED OCCUPANCY CHARGES

In an earlier part of the work reference was made to the base schedule frequently being a small schedule of itself and an illustration was given of the manner in which a base rate of a printer on the old type of manufacturing schedule was made up. It is not possible, in many cases, to use for a base rate or for schedule charges one set of charges. It is necessary to go beyond in the case of many risks and compute the base or occupancy charge for the individual risk. To charge an amount which would be sufficient to cover the large risk would be an imposition upon the smaller risk. In the case of stocks as boots and shoes, hardware, dry goods, etc., the size of the stock has nothing to do with the susceptibility to damage. Passing beyond the mercantile division, however, and coming to department stores, wholesale grocers, printers, machine shops, and risks of that character where there may be several hazards assembled under one roof, or where there may be an increasing hazard with the increasing of a number of machines, it is necessary to treat the base rate specifically and to treat the occupancy charges in a graded manner.

The universal schedule makes divisions for graded charges, illustrations of which are as follows:

Wholesale Grocers

	Add for Build'g Rate Cents	Add for Contents Rate Cents
Class A. Without manufacturing or any of the additional hazards specified below		40
Class B. If bottling wines, liquors, olive oil, bluing, or other preparations, with packing	10	40
Class C. If mixing and packing flour, starch, baking powder, cereals, or similar substances; Or if printing	15	45
Class D. If manufacturing flavoring extracts, essences or drugs; Or if rectifying by cold process only; Or if molasses reboiling or maple syrup mixing; Or if coffee milling, polishing, separating, mixing and grinding, with power; Or if fruit cleaning with power or dry room, or bleaching with sulphur	30	50
Class E. Or if coffee roasting, using only gas fuel standard equipment, fireproof floors, metal cooking pans, metal troughs, metal conveyors and metal hoods over roasters; Or if spice grinding with modern iron frame mills	40	60
Class F. If coffee roasting, standard equipment, using other than gas fuel	50	70
Class G. If spice grinding with wood frame mills	75	75
Class H. If coffee roasting, old style equipment, wood floors, wood cooling troughs, or wood conveyors	1.25	1.10

Charges are not cumulative. The higher rate in each case includes the less.

Coffee Preparing Establishments

Class A. Coffee milling, polishing, separating, mixing, grinding, etc., with power	30	60
Class B. Coffee roasting, using only gas fuel, standard equipment, fireproof floors, metal cooling pans, metal troughs, metal conveyors, and metal hoods over roasters	50	75

	Add for Build'g Rate Cents	Add for Contents Rate Cents
Class C.		
Coffee roasting, standard equipment, using other than gas fuel	**75**	**85**
Class D.		
Coffee roasting, gas fuel, standard equipment except floors built of wood well covered with brick or cement	**75**	**85**
Class E.		
Coffee roasting other than gas fuel, non-standard equipment, non-fireproof floors, etc., not less than	**1.50**	**1.20**

Department Stores

	Add for Build'g Rate Cents	Add for Contents Rate Cents
Class A.		
All or any of the following:		
Dry goods, Carpets, Rugs, Boots and Shoes, Dressmaking, Toilet Goods, Upholstery Stock (materials only), Millinery, Clothing, Livery, Cloaks and Mantillas, Hats and Caps, Photographic Supplies, Fancy Goods, Books and Stationery, Silverware, Jewelry, Bags and Pocketbooks, Chinese and Japanese Goods, Restaurant (cooking safely arranged)	**20**	**55**
Class B.		
If, also, any or all of the following:		
Bronzes, Glassware, Crockery, Lamps (all packing material in bins; if not in bins charge under faults of management No. 143, 15 cents), Upholstery (curtain making only), Bric-a-brac and Curios, Trunks (no repairing), Toys, Sporting Goods, Fishing Tackle, Guns, Bicycles, Sewing Machines, Harness and Horse Supplies, Photographing, Wines, Liquors and Cigars, Canned Goods, House-furnishing Goods, Kitchen Goods, Carriages, Pictures and Frames (no work)	25	60
(This rate covers, also, Class A, the higher rate including the less.)		
Class C.		
If, also, any or all of the following:		
If repairing trunks, or picture framing	35	60
Furniture, Mattresses, Wood and Willow Ware	40	70
If repairing, varnishing or upholstering furniture, mattress making other than hair	50	70
If hand picker, not in fireproof room add 25 cents to first column.		
(These rates cover also Classes A and B, the higher rate including the less.)		
Packing and unpacking not cut off add 10 cents to first column.		

	Add for Build'g Rate Cents	Add for Contents Rate Cents
In packing room cut off and sprinklered, deduct 10% from first column charge—unless deduction has been allowed for Automatic Sprinklers.		
Power. Steam or electric for running shafting, increase first column charge of class 10 cents.		
Organization of employes for extinction, fire drill, etc., deduct .02 from both columns.		

In several other cases the occupancy charges proceed by far less minute gradings than noted in the three examples given. Printing is taken care of in some seven different classes, the last class with a first column charge of forty cents and a second column charge of sixty cents is for a printer using steam or electric power and having one large or three small presses. Should he have more presses five cents is added for each large press or three small, but the charges must never exceed seventy-five cents for the first column and one dollar and twenty-five cents for the second column charge.

SPRINKLERS

The sprinkler device is recognized as the most efficient factor in the fighting of fire. Like most other things which enter into the fire prevention and fire insurance problem it has required years to educate the insured and insurer to the proper appreciation of this valuable device.

Early Schedules. On September 29, 1884, the first building fully equipped with sprinklers in accordance with the rules adopted in New York City was approved. The method of installation and rules in force today have been duly set forth in other parts of this series of books, but there remains for consideration the special matter of the allowance made in the insurance rate for sprinklers.

In the beginning the allowance was rather small, seven and one-half per cent and under a slightly different condition ten per cent. The growth of the sprinkler equipments was very slow. In the first two or three years after 1884 probably not fifteen buildings were equipped in the larger cities. From that time on the growth has been quite rapid. After a while the allowance was advanced to twenty per cent and continued at that point until 1896 when experience led to the drafting of new rules, the adoption of new standards and an inducement made to secure two sources of water supply for the equipment. When the equipments were installed under the new rules in 1896, with two sources of supply, an allowance of thirty per cent was made in the rate of insurance. It was thus possible for the property to receive an allowance of twenty or thirty per cent depending wholly upon the standard of equipment put into the building.

Higher Sprinkler Schedule. In 1905, there was adopted a schedule for more completely measuring sprinkler equipments. It amounts to nothing more or less than a specific schedule built on the usual schedule lines, a series of items for measuring the efficiency of a sprinkler system in any building. With the adoption of this schedule another advanced step was taken in regard to allowances and it is possible under the schedule to obtain an allowance of fifty per cent in the rate of insurance. The schedule makes provision for allowances running from fifty per cent down to one per cent, but it is considered that an equipment with less than ten per cent allowance is not of any value and no allowance is granted therefor. It cannot be emphasized too strongly, of course, that a cup of cold water at the proper time would put out any fire that starts. The sprinkler device is the nearest approach that man has attained to having the cup of cold water ready to throw on the fire when the fire starts. Inasmuch as the fire opens the sprinkler head and starts the water, it may be said to commit suicide by pouring the water on itself.

Although the equipment may be one having a very low grade it may serve to catch many a fire in its incipient stage and the records of these minor equipments has been very favorable. At the same time, the low grade equipments have a very small degree of efficiency compared with those receiving a higher grade. It is a fairly accepted principle now that an equipment with a grading of sixty per cent for which an allowance is made in the rate of insurance of thirty per cent is a type of equipment which will hold the fire in control. Below that point good practice would deem that the equipment was sub-standard, and above that point experience teaches that the efficiency is marvelously increased.

Care of Sprinklers. The sprinkler equipment in its care requires constant vigilance and a number of devices have been put upon the market to keep an absolute check at all times upon the sprinkler system. Severe losses have occurred where the water has been shut off or the equipment in some manner tampered with, the fact not being discovered until the fire breaks out and the equipment is out of commission. The most recent device for overcoming this lack of knowledge concerning a sprinkler equipment at all times is what is known as a central station supervisory system. The system is extremely sensitive to any changes in the sprinkler service and promptly registers at a central office any flowing of the water in the pipes or any tampering with the valves or any disturbance in the system whatever. The value of supervision is recognized by an increased allowance for the sprinkler service and beyond the fifty per cent which may be reached by the grading schedule an additional twenty per cent in some parts of the country is granted for the supervisory service, thus making an allowance of sixty per cent in all.

Sprinkler equipments have up to date been practically confined to those properties which owing to the amount of insurance were able to show that within three or five years the saving in insurance would be sufficient to pay for the sprinkler system. There have been, of course, many cases where the system has been installed by the owner for the express purpose of preventing a fire and the financial consideration was of secondary moment. That is not so, however, in the great majority of cases. In fact, in the present state of the public opinion concerning fire prevention nearly every fire prevention device is expected to return, in reduced rates of insurance, its cost in a few years. In the continental countries where rates are so much lower than they are in the United States and Canada, normally not more than five per cent return on the cost of the sprinkler equipment can be made by the changes in the rate of insurance. In other words, the rates there are so low already that there is not much margin to work on.

Grading Schedule. The grading schedule for measuring the sprinkler efficiency is as follows:

SCHEDULE FOR GRADING SPRINKLER PROTECTION

Name of Risk ________________ *Survey No.* ______________ *Map No.* ____

Street Location ____________________________________ *Date* __________

WATER PRESSURE

NOTE. Gravity tanks with bottoms less than 8 feet above highest line of sprinklers, or public water-works systems giving less than 15 lbs. on highest line of sprinklers, or pump without constant power, or with either power plant or pump disadvantageously located are not recognized supplies.

(1) Deficient primary pressure from gravity tank giving less than 25 lbs. at highest line of sprinklers, but with tank bottom not less than 20 feet above highest line of sprinklers.......... 10%

(2) Deficient primary pressure from gravity tank giving less than 25 lbs. at highest line of sprinklers, and with tank bottom less than 20 feet, but 12 feet or more above highest line of sprinklers.......... 20%

(3) Deficient primary pressure from gravity tank giving less than 25 lbs. at highest line of sprinklers, and with tank bottom less than 12 feet but 8 feet or more above highest line of sprinklers.......... 30%

(4) Deficient primary pressure from public water works system giving less than 25 lbs., but more than 15 lbs. on highest line of sprinklers. (See Sprinkler Rules, Section "J," Note to Rule 1.).......... 20%

(5) Secondary supply deficient pressure from gravity tank, with bottom less than 20 feet, but 12 feet or more above highest line of sprinklers.......... 5%

(6) Secondary supply deficient pressure from gravity, tank with bottom less than 12 feet, but 8 feet or more above highest line of sprinklers.......... 15%

(7) Secondary supply deficient pressure from public water-works system, giving less than 25 lbs., but more than 15 lbs. on highest line of sprinklers. (See Sprinkler Rules, Section "J," Note to Rule 1.).......... 10%

(8) High primary pressure dependent upon an automatic pump.......... 10%

CAPACITY OF WATER SUPPLIES

(9) Each water supply deficient in available capacity more than 50% shall not be recognized as a supply.

A—Deficient	20% to 1%	(inc.) of requirements,	deduct.	5%
B— "	30% to 21%	"	"	10%
C— "	40% to 31%	"	"	15%
D— "	50% to 41%	"	"	20%

(10) No recognized secondary water supply.......... 30%

EQUIPMENT

Old or imperfect devices. Sprinklers or Dry Valves containing defects and yet judged of some value and installed at some past time, under the then existing rules, are not approved for full credit and not over 10% deduction from unsprinklered rate shall be allowed for systems in which they are employed.

NOTE. A check valve maintained under air pressure to constitute a dry system is not an approved dry valve. Premises not Completely Protected by Distribution of Water from Sprinklers, due to

(11) Roof construction comprising an unsprinklered blind attic or concealed spaces, without open communication from story beneath.......... 10%

(12) Unsprinklered small enclosures.......... 10%

(13) Other minor unsprinklered portions.......... 10%

No charge for absence of sprinklers at dynamos and switchboards when in fireproof rooms not containing other combustible material.

(14) A small number of sprinklers with water supply shut off during cold weather	5%
(15) Water distribution obstructed by shelves, tables, benches, partitions, etc	10%
(16) Obstruction by piles of combustible stock or other contents	10%
(17) Clear space of 2 feet below ceiling or bottom of joists not maintained throughout all sprinklered areas	10%

Omit 15, 16, and 17, if charged under OCCUPANCY

(18) Over 25% of sprinklers on dry system	20%
(19) Over 20% of the number of sprinklers in any one "area" of "extra high test solder"	20%
(20) No approved alarm valve service	20%

For absence of approved alarm valve service, where approved watchman service exists, charge 10%.

(21) Other (minor) deviations from equipment rules	10%

Pipe sizes and spacing according to New York Board Standards existing prior to April 15, 1896, to be charged for under this item.

VERTICAL OPENINGS

(22) Unstopped openings between floors without approved curtain boards	15%
(23) do. with approval curtain boards	5%

MAINTENANCE

(24) No approved sprinkler equipment inspection system	30%
(25) Minor corrosion, rust, or mechanical injury to sprinkler system apparatus	10%
(26) Minor defects from lack of maintenance, other than noted under No. 25	10%

OCCUPANCY OR CONSTRUCTION NOT CONDUCIVE TO POSITIVE CONTROL OF FIRE BY SPRINKLERS

(27) Large area and unusual height of room, with occupancies likely to cause the operation of over 50 sprinklers in one fire, such as theaters and halls	20%
(28) Contents preventing full sprinkler distribution, as stored cars, except when buildings are equipped with "carline" sprinklers, barrels, coffins, large hollow piles of combustible stock, such as furniture	20%
(29) Unusual draught conditions, as from large blower systems, or buildings having open sides	20%
(30) Sugar refineries	25%
(31) Apprehensive flash fire hazards, as with grain elevators, oatmeal, cereal, flour, and grist mills, starch manufacturing, carbon or cork grinding, coal pulverizing, certain wood-working processes, stored hemp, jute or sisal	30%
(32) Occupancy allowing quick hot fires, not readily extinguished with water as in varnish works, oil, and lard refineries, and properties containing large quantities of grease and fats	40%
(33) Apprehensive explosion hazards, due to presence of gunpowder, dynamite, various chemicals and compounds, etc., or	
(34) Vapors from dangerous quantities of naphtha, alcohol, etc., or	
(35) Manufacture of pyroxiline products, such as celluloid, or storage or use of same in quantity	50%

Operation. The operation of the schedule is simple. It assumes an equipment of the highest grade of one hundred per cent and then if the first item should apply as a deficiency, namely, item No. 1, ten per cent should be deducted from this, leaving ninety per cent. The next item of deficiency, for instance, No. 6, if it applied would affect a reduction of fifteen per cent in the ninety per cent, and so on until the final result is reached.

Restricted Sprinkler Schedule. Until 1905, the only effect in the rate of insurance by sprinkler installation (and it will be appreciated that effect may be a very large one, since it means a reduction if the equipment is standard of fifty per cent, and with the supervisory system a possible sixty per cent), had proceeded along the lines followed when the allowance was first made for the device, that is, it had only affected the rate by making a percentage reduction.

Experience with several thousand equipments which had been installed, proved that if properties of certain occupancy, certain construction, and freedom from exposure were equipped with sprinklers of a high grade of efficiency that the chances of controlling a fire in that property were so excellent as to lead to consideration being given to the question as to whether a different method of treating sprinkler risks might not be adopted. In short, it is now considered an axiom in the handling of sprinkler properties that height and area are not of much moment if the equipment be of a reasonable grade of efficiency. This led to the formulation of a special schedule known as the restricted sprinkler schedule for use in the rating of sprinkler properties under the conditions laid down in the schedule. The schedule must be allowed to speak for itself and it does so in the following language:

RESTRICTED SPRINKLER SCHEDULE

Restricted in Application to Risks Complying with Limitations

			Building	Contents
A COST OF INSPECTIONS AND OTHER RUNNING EXPENSES.				
(1) If Total Fire Insurance maintained is less than $100,000	.12	Charge both Building and Contents.	....	1
(2) If Total Fire Insurance maintained is less than $200,000	.10		....	2
(3) If Total Fire Insurance maintained is less than $500,000	.075		....	3
(4) If Total Fire Insurance maintained equals or exceeds $500,000	.05		....	4

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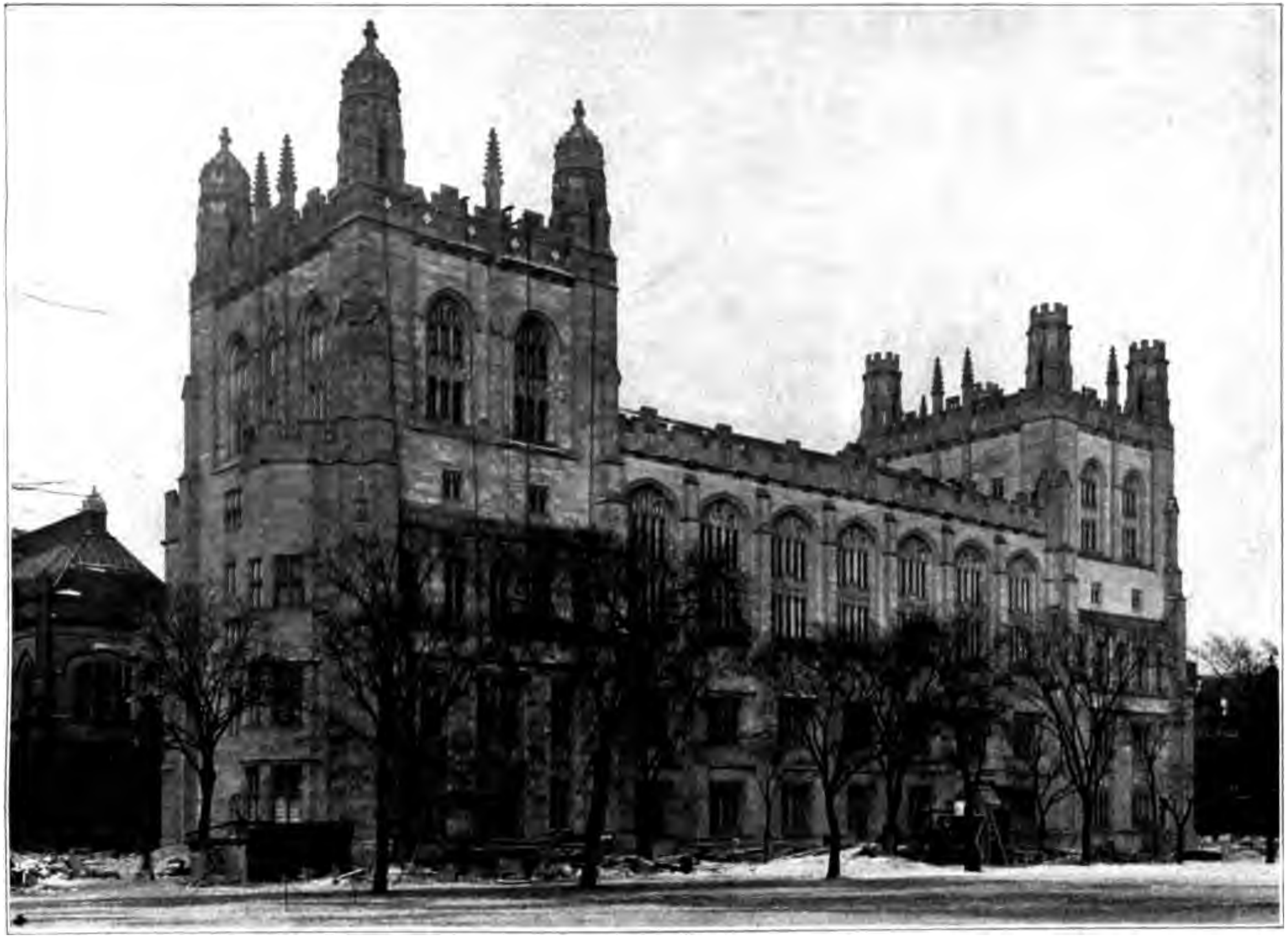
TILDEN FOUNDATIONS



HARPER MEMORIAL LIBRARY BUILDING AT THE UNIVERSITY OF CHICAGO

Building | Contents

B COST OF INHERENT FIRES

(5) Grade of Automatic Sprinkler Equipment is.......................... %

(6) Grade of Occupancy, viz: X, Y or Z is..

CHARGE FOR SUCH GRADE AND OCCUPANCY AS PER FOLLOWING TABLE, INCREASING THE CHARGE 10% IF OPENINGS THROUGH FLOORS ARE NOT PROPERLY ENCLOSED.

	Grading of Sprinkler Equipment	OCCUPANCY GRADE									Contents
		In Ordinary Building			In Slow Burning			In Fireproof or Semi "			
		X	Y	Z	X	Y	Z	X	Y	Z	
(7)	100	.11	.17	.33	.10	.15	.30	.09	.13	.27	 7
(8)	95	.13	.20	.39	.12	.18	.35	.11	.16	.31	 8
(9)	90	.14	.22	.44	.13	.20	.40	.12	.18	.36	 9
(10)	85	.17	.25	.50	.15	.23	.45	.14	.21	.40	10
(11)	80	.18	.28	.55	.16	.25	.50	.15	.23	.45	11
(12)	75	.20	.31	.61	.18	.28	.55	.16	.25	.49	12
(13)	70	.21	.33	.66	.19	.30	.60	.17	.27	.54	13
(14)	65	.23	.36	.72	.21	.33	.66	.19	.30	.58	14
(15)	60	.25	.39	.77	.23	.36	.71	.21	.33	.63	15

(16) IF CONDITIONS ARE SUPERIOR FOR THE CLASS IN "X" AND "Y" GRADE OF OCCUPANCY, THE ABOVE CHARGES MAY BE REDUCED FROM 10 TO 35 PER CENT.

(17) FOR STANDARD SPRINKLER SUPERVISORY SERVICE REDUCE THE ABOVE CHARGES 25 PER CENT.

IF CONDITIONS ARE BELOW AVERAGE FOR THE CLASS OF OCCUPANCY, CHARGE NOT EXCEEDING THE FOLLOWING:

(18) In construction.................... .15 18
(19) In internal management and conditions .15 19
(20) In safeguarding of special hazards in X grade of occupancy.............. .10 20
(21) In safeguarding of special hazards in Y grade of occupancy.............. .20 21
(22) In safeguarding of special hazards in Z grade of occupancy.............. .30 22

Charge Contents Only

CHARGE TO BUILDING FOR INHERENT FIRE COST THE FOLLOWING PER CENT OF THE SUM OF CONTENTS CHARGES UNDER ITEMS 7 TO 22 INCLUSIVE (BUILDINGS OF FIREPROOF, SEMI-FIREPROOF AND SLOW-BURNING CONSTRUCTION to take the "X" GRADE):

(23) "Ordinary" viz: wood joist floors and roofs and/or wood walls........... 65% 23
(24) "Slow-burning" viz: plank and timber floors........................... 55% 24
(25) "Semi-Fireproof" viz: structural metal members not insulated with approved tile or concrete............. 45% 25
(26) "Fireproof" viz: structural metal members correctly insulated with approved tile or concrete... .... 30% 26

Charge Building Only.

	Building	Contents
C **COST OF EXPOSURE**		
(27) For exposure apply Exchange Exposure Table, modified as below, and add the charges to both building and contents rates.	....	27

MODIFICATIONS IN EXCHANGE EXPOSURE TABLE FOR APPLICATION TO RISKS RATED ON RESTRICTED SPRINKLER SCHEDULE.

No consideration shall be given to nonstandard window protection.

In all cases the unsprinklered rate of risk to be rated shall be taken as the base.

Buildings having automatic sprinkler equipments grading 60 per cent or over, or churches, dwellings, stores and dwellings, school houses, apartment houses and hotels, if of fireproof construction, or not exceeding five stories in height, shall not be considered as forming exposures.

No charge shall be made for frame exposure unless exposure is in excess of 1,000 square feet per floor, and/or over two stories in height.

No charge shall be made for height of risk to be rated.

The charge to stock to be from 10 to 30 per cent greater, according to susceptibility, than to building.

The final charge produced by application of exposure table shall be reduced by the percentage allowance for automatic sprinkler equipment.

	Building	Contents
D COST OF TAXES AND COMMISSIONS.		
(28) Increase the building and contents rate by...... per cent according to district in which risk is located.		
Total or Final Rate	....	28

OCCUPANCY GRADING TABLES "X", "Y", "Z", GIVING GRADES OF OCCUPANCY TO BE USED IN CONNECTION WITH SCHEDULE FOR RATING SPRINKLERED RISKS (RESTRICTED)

NOTE.—These three groups are relative in respect to fire cost as influenced by frequency or susceptibility, "X" having the lowest cost, "Z" the highest. The occupancies listed in each group need not always be so classified. They, however, show the judged correct placing of the average risk. Individual cases with peculiar features will be met and must be graded "X", "Y", or "Z", according to the best judgment of the Underwriter.

"X"

Bakeries (superior)
Bleach, dye, and print works
Clothing, shirt and collar manufacturing (excluding oil clothing and rubber garments)
Cop yarn knitting
Cotton mills
Cotton warehouses (superior)
Leather glove manufacturing
Manufacturing from silk
Metal working (superior)
Paper manufacturing
Piano assembling and finishing (superior)
Rubber manufacturing
Tanneries (superior)
Warehouses (excluding hemp, jute and drugs)
Weaving
Wholesale mercantile (without serious associated manufacturing hazards)
Worsted and woolen manufacturing (medium and high grade stock)

"Y"

- Automobile storage and repairs
- Bakeries (average)
- Baking powder manufacturing
- Bluing manufacturing
- Candy manufacturing
- Canning establishments
- Card clothing manufacturing
- Cotton warehouses (average)
- Electric traction property (superior)
- Hat manufacturing
- Harness and saddlery manufacturing
- Hotels
- Leather board manufacturing
- Manufacturing of brushes and brooms
- Marble and stone works
- Metal working (average)
- Paint manufacturing (superior)
- Piano assembling and finishing (average)
- Piano manufacturing
- Pocket book manufacturing
- Printing and binding
- Rattan goods manufacturing
- Retail mercantile (other than department stores) and open wholesale stocks
- Shoe manufacturing
- Stables
- Tanneries (average)
- Tobacco manufacturing and storage
- Trunk manufacturing
- Wall paper, coated paper, playing card manufacturing
- Whip manufacturing
- Wool pulling and scouring
- Wood-workers with slight dust, shaving, varnishing, and painting hazards
- Writing ink manufacturing

"Z"

- Cotton and linseed oil mills and refineries
- Curry shops
- Drugs, manufacturing or wholesale (where not violating Item 31 "Automatic Sprinkler Protection Grading Schedule")
- Electric traction property (average)
- Fire brick and tile works
- Glass works
- Hemp and jute manufacturing, or storage (where not violating Item 29 "Automatic Sprinkler Protection Grading Schedule")
- Knitting mills (full process)
- Mattress and upholstery shops
- Paint manufacturing (average)
- Potteries
- Printing and lithographing ink manufacturing
- Rag stocks
- Rubber reclaiming
- Sweat shops
- Wool mills (low grade stock)
- Wool shoddy manufacturing
- Woodworkers with notable hazard from sawdust shavings, painting, and varnishing (where not violating Items 27, 28, 29 and 32 "Automatic Sprinkler Protection Grading Schedule")

Limitations in Application of Schedule for Rating Sprinklered Risks

This schedule is restricted to the rating of risks whose hazard of occupancy is under positive control by the sprinkler system as installed and maintained therein, such risks not being subject to serious local exposure; and its application is subject to the following limitations:

(1) It shall not apply to risks having defective sprinkler equipments graded at less than 60% of full standard by application of the "Automatic Sprinkler Protection Grading Schedule."

(2) It shall not apply to risks of ordinary construction, having hollow walls, hollow ceilings and/or unprotected openings through floors, nor to those of concrete block or cement block construction.

(3) It shall not apply to risks having an exposure charge which, under provision of Section "C" above, exceeds 10c. on the contents. It shall not apply to risks communicating with other risks having sprinkler equipments grading less than 60 per cent. No charge shall be made for communication with other sprinklered risks eligible for rating under this schedule.

(4) It shall not apply to Department Stores, or to risks having occupancy or construction not conducive to positive control of fire by sprinklers, as per "Automatic Sprinkler Protection Grading Schedule," Items 26 to 33, inclusive.

(5) It shall not apply to risks containing more than two manufacturing tenants, unless the building is of good fireproof or mill construction with all vertical openings cut off in an approved manner, in which event the building shall take the "X" occupancy grading, and the various contents grade according to their class.

(6) The following clauses are required for risks rated under this schedule: Automatic Sprinkler; Electric Light; 90% Coinsurance; Central-Station Thermostat or Central-Station Valve Alarm, or Watchman and Clock. The final rates under this schedule are net and are not subject to any further deductions whatsoever, either for the above clauses or for 100% Coinsurance Clause, or for any other feature.

(7) Rates are for one year term. Short rates required for less than one year. Buildings or contents may be written for 2.7 rates for three years, or 4.3 rates for five years.

(8) Use and Occupancy insurance liable in event of a loss to the building and/or machinery may be written for $\frac{8}{10}$ of the building rate. Use and Occupancy insurance liable in event of a loss to contents may be written at $\frac{8}{10}$ the contents rate. Rents insurance may be written at $\frac{8}{10}$ the building rate. Insurance of commissions on goods shall be rated the same as the contents.

(9) Blanket rates for sectional risks, and also for building and contents, may be promulgated upon satisfactory ascertainment of distributed values.

It has now been in use for nearly six years in different parts of the country and has given great satisfaction as a method of handling sprinkler business. It illustrates very well the process of evolution which is steadily taking place in fire insurance rating.

It should be noted that it only applies to properties of a certain class and these are very specific classes. Other classes as department stores are excluded and under general language risks which may not be subject to positive sprinkler control. The average rates produced by this schedule will run about twenty-five cents on the contents and between ten and fifteen cents on the building.

FIRE INSURANCE RATING

PART III

DEAN ANALYTIC SCHEDULE

MERCANTILE CLASSES

In previous parts the subject of rating has been considered and a survey given of the various systems in use, except the one noted at the head of this part. That system is now to be examined. In a personal letter received from A. F. Dean, of Harding & Dean, managers of the Western Department of the Springfield Fire and Marine Insurance Company, of Springfield, Massachusetts, the general historical dates, dealing with the beginning of this system, bringing the various editions down to the present time, are set forth as follows:

> It began with a paper read before the Missouri, Kansas, and Nebraska Fire Underwriters Association in 1880, on the subject of "Irregular Frame Exposures." This paper embodied some formulas on the subject which I personally used for many years. On July 17, 1889, I formulated a schedule, at the request of the companies, along the same line of reasoning, but it was not adopted because of its being regarded as too complicated. On December 11, 1902, I issued a pamphlet entitled "Exposure Formulas and Basis Tariff for Frame, Iron-Clad, and Brick-Veneered Buildings and Contents." This was at once put to use for practical rating purposes in Illinois and several other states. On March 11, 1903, I completed a basis tariff for brick buildings and contents, which was also put to immediate use by the companies. On June 27, 1903, I issued a second edition combining the two tariffs above named, under the title of "Mercantile Tariff Exposure Formulas" for the Measurement of Fire Hazard, which also went into immediate use as a rating tariff for the smaller towns, but the use of it in larger towns required various expansions, and on October 17, 1904, I issued a new edition under the name of "Analytic System for the Measurement of Relative Fire Hazard." Immediately after the Baltimore fire I was asked to expand the system so as to cover the large cities in lieu of the tariffs that had been in previous use. This was done, but

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the tariff did not go into use until immediately after the San Francisco conflagration. On June 15, 1906, the edition for large cities was issued and has been in use ever since, being expanded from time to time as new problems arose.

Three principles are considered somewhat basic in the Analytic System or, as they are called, three classes of hazards:

(1) The hazard inherent in or about the risk itself, such as construction, occupancy, protection, and exposure.

(2) The element of place, dealing with the different amounts of losses in different localities on the same classes of risks.

(3) The element of time, which takes into consideration the loss changes from year to year in the country as a whole, in a given state or in a smaller geographical division.

Rates are considered as made up of a large variety of quantitative relations. They must be measured by an empirical standard which can be applied to all classes dealt with by the schedule and at all times on the principle that a yard stick may measure twenty-one yards or one hundred yards. This *relativity*, as it is termed, is secured by means of a percentage system of charges after the base rate is once adopted. In the Universal Mercantile Schedule, as pointed out in Part II, all the charges for defects such as a non-standard chimney, non-standard floor openings, etc., are a fixed charge, generally so many cents added to the base rate. Percentages in the Universal Schedule are not dealt with except in the making of reductions for various fire appliances and some other items and for coinsurance. In the Analytic System, however, percentages are used rather than fixed amounts, almost entirely throughout the work. This is departed from in two particulars which will be noted in due course. But where, for a defective chimney, the Universal Mercantile Schedule would add a certain number of cents, as twelve, the Analytic System would make a percentage increase as 10 per cent of the base rate. The reasons for the percentage charges have been set forth by one writer, H. M. Hess, now manager of the Missouri Rating Bureau, in the following language:

> If the consensus of underwriting judgment and experience decides that the charge for a stovepipe through a roof should be two times the charge for a brick chimney on brackets, this relation should be the same in a building with protection and a building without protection; in a building in Texas and a building in New York; in a building today and a building next year, when rates may have been put up or down to provide for changing experience. If

the consensus of underwriting judgment decides that the charge for a stovepipe through a roof should bear a certain relation to the charge for the unanalyzed hazard, namely, the basis rate, this relation should be the same in buildings with and without protection, in Texas and New York, this year and next year. Obviously, the only way to keep constant these relations of unanalyzed and analyzed hazard is to make the charges for them percentages, and always to use these same percentages wherever the hazards which they cover are found. The only hazard that is common to all risks is the unanalyzed hazard, and, therefore, the only "charge" that is found in all risks is the basis rate. For this reason the charges for analyzed hazard are made percentages of the basis rate, and we are thus enabled to maintain constant relations among individual charges and between any individual charge and the basis rate. When the difference in experience in two states calls for different estimates in those states we can then assume different basis rates, and know that the same relation existing between the two basis rates exists between the final estimates on similar risks in the two states and also between the various charges for similar defects in each risk. Also when the difference in experience from year to year calls for a change in estimate, we can change the basis rate and be sure that the same relations will continue to exist.

Percentage Charges Illustrated. As this point is the pith of the whole matter and should be most clearly understood, I will illustrate: Assume the basis rate for all brick buildings in the year 1908, one story high, and without protection, to be 80 cents. In 1913, five years later, assume the basis rate for the same class of building will be 60 cents, which is 20 cents, or 25 per cent, lower than the basis in 1908. Assume a stovepipe through the roof, for which the charge is 15 per cent. In 1908 the charge is 15 per cent of 80 cents, or 12 cents. In 1913 the charge will be 15 per cent of 60 cents, or 9 cents. 9 cents is 3 cents, or 25 per cent, less than 12 cents. We thus have the same relation between the two stovepipe charges that we have between the two basis rates. Also assume an occupancy charge of 45 per cent. In 1908 the charge is 45 per cent of 80 cents, or 36 cents. In 1913 the charge will be 45 per cent of 60 cents, or 27 cents. 27 cents is 9 cents, or 25 per cent, less than 36 cents. We thus have the same relation between the two occupancy charges that we have between the two basis rates. Also please observe that the charge for the assumed occupancy is three times the charge for the stovepipe in 1908, as well as in 1913. 36 cents is 3 times 12 cents; 27 cents is 3 times 9 cents. If we now assume that this defect and this occupancy are all that can be charged, we figure total charges of 15 per cent plus 45 per cent, or 60 per cent. In 1908 the final estimate on the building is 60 per cent of 80 cents, or 48 cents, plus 80 cents, which gives $1.28. In 1913 the final estimate will be 60 per cent of 60 cents, or 36 cents, plus 60 cents, which gives 96 cents. 96 cents is 32 cents, or 25 per cent, less than $1.28. We thus have the same relation between the two final estimates that we have between the two basis rates, or between the two occupancy charges, or between the two stovepipe charges; and furthermore, the basis rate, stovepipe charge, occupancy charge, and final estimate in 1908 bear the same relation to each other that they will in 1913. If the occupancy is three times as hazardous as the stovepipe in 1908, it will be three times as hazardous in 1913, and we have it so charged. Thus by a difference in basis rates, we are able to bring about any desired difference in final estimate due to a difference in experience, without changing the relations among the various charges for hazards that can be or can not be analyzed. Again, quoting from the preface of the Analytic System, we read:

> A tariff constructed of fixed charges and credits—in other words, a tariff in which the principle of relativity is not recognized—must, of necessity, be an unstable compound of unrelated parts. It can not be expected to serve its purpose for any length of time, because every important change in loss ratios, which are always changing, necessitates its reconstruction or abandonment through a percentage advance or reduction which, applied as it is to rates out of relation to each other, breeds trouble.
>
> A tariff built upon the corner stone of relativity when once established becomes an organic whole—an instrumentality of logically-related parts which no future exigencies of the business need ever disturb. It becomes a permanent instrument for measuring hazard, and while it is conceivable, even probable, that a new tariff so constructed may require a period of adjustment to develop consistency in all its parts, when this consistency has been finally established to conform to the best underwriting judgment, it becomes a finished structure, a permanent body of relations for the measurement of fire hazard. While it may become necessary from time to time to insert some new charge or credit to fit an innovation in hazard, aside from this necessity it is safe to assume that, once completed, it will be as unnecessary to rebuild a tariff so constructed as it is to rebuild the compass, chronometer, or thermometer.

The schedule is the result of a process of evolution, as shown in the letter by Mr. Dean. Indeed, it would be impossible to overpraise him for the immense labor which he devoted unselfishly to the perfecting of the system after he had once conceived it. With a full schedule for examination it is perhaps difficult to realize the immense number of hours that went into its construction. Mr. Dean has stated:

> Charges and credits are necessarily provisional assumptions: The most we can claim for them is that they are based upon unit, judgment, and experience through which alone approximate truth can be estimated. While even this will admit of debate, for they have been a source of much controversy, there is no disputing the fact that the specific charges and credits (for in them the evidences of abstract fairness applying to features common, perhaps, to all the risks of a class or to a large proportion of the risks in many classes) are free from the possibilities of personal favoritism. It is proper to assume that as many of these elementary factors will be too low as too high, but when a risk is unduly taxed in one charge it is reasonably sure to be insufficiently taxed in another. From these leveling influences, it is safe to assume that each charge is automatically regulated within the limit, not far from the true mean.

Such are the principles on which the schedule is founded and the reasons as set forth by its exponents.

There is now left for consideration the schedule itself. It should be pointed out that the schedule is copyrighted and copies can be secured from the proper authorities having charge of the schedule. It is true of this schedule, as it is of the Universal, that one needs the complete copy of either schedule in order to thoroughly master the subject. It is, however, equally true of both schedules that a clear idea can be obtained of their general workings without the actual volumes before us. It is always necessary for a rate to commence somewhere or with something, and the Analytic does not differ in this respect from all the other schedules that have been devised. It must, of necessity, have a starting point and that starting point is the basis. It is based, as in the Universal, and, as a matter of fact, as such bases have generally been made, on the general conditions dealing with public fire construction in any locality to which the schedule is being applied. In the western part of the country, with headquarters at Chicago, the general body which has had charge of the fire insurance interests or represented them in a larger way, is a body known as the Western Union, or more briefly called the Union, that it might not be confounded with the telegraph company. The Union divides municipal and public protection into seven grades, the essential facts in each grade being substantially as follows:

First Class. *Waterworks.* Gravity, combined, or direct-pressure system, with reservoir or standpipe, pumps and boilers of specified capacity, and with pumping station, pressure, mains, gate valves, and hydrants as specified. Approved high-pressure system.

Fire Department. Equipment of apparatus, full-paid men, hose, and telegraph fire-alarm system as specified.

Ordinances. Approved building, electrical and general ordinances. Streets of standard width, paved and lighted.

Second Class. *Waterworks.* Same as first class, except pumping station may be brick instead of "fire resistive," and a slight deficiency may exist in location of gate valves. No high-pressure system.

Fire Department. Same as first class, except requirement for number of men may be reduced as specified.

Ordinances. Same as first class, except that wires need not be installed in underground conduits.

Third Class. *Waterworks.* Pressure mains and hydrants same as first class. Other requirements not less than 75 per cent of first class. Force mains need not be in duplicate. Pumping station same as second class.

Fire Department. Same as first class, except requirement for number of men may be reduced as specified. Fire-alarm system need be only 75 per cent of first class.

Ordinances. Suitable, but without special supervision. Streets, however, to be same as first class.

Fourth Class. *Waterworks.* System may be 50 per cent of first class, mains and hydrants slightly deficient, but pressure standard.

Fire Department. Organized and well-drilled volunteer. To be paid for services rendered. Not less than one hook and ladder truck and one hose reel with 1,500 feet of standard hose, drawn by horses. Satisfactory telephone system for fire alarm.

Ordinances. Same as third class. Streets same as first class in business district.

Four and One-Half Class. *Waterworks.* System not up to standard of fourth class.

Fire Department. Slightly deficient from fourth class.

Ordinances. None.

Fifth Class. *Waterworks.* None.

Fire Department. Volunteer with one hand engine, 500 feet of standard hose, and public cisterns. A double-tank chemical engine may be used in place of a hand engine.

Ordinances. None.

Sixth Class. No fire protection.

Briefly expressed, the Analytic System has no base rate, but contents itself with adopting the base rate furnished by the Western Union. Two of these basis rates for any one locality are used, the brick basis rate and the frame basis rate.

ITEMS CONSIDERED IN COMPUTING RATE

It is now necessary to take up the various items which are considered in computing the rate, the basis rate having been established.

Height. A one-story building is assumed as a standard and for each story over that an additional charge is made. The increasing stories call for higher charges until a point is reached where the higher protection is considered of no value. Beyond that point the amount charged is the same for each story. If there be no basement in the building, a reduction is made from the basis rate, while subbasements are charged for by an addition. In the case of the height charge, in order to secure a higher charge for each succeeding story, the charge for the second story, for instance, is added to the one-story charge, and this sum used as a basis for the succeeding charge, and so on for any number of stories.

Area. One thousand square feet constitutes the unit or standard of measurement for area. All in excess of that is charged. The charge for area is not made, as in the case of height, by establishing a new basis rate each time on which to base the future charge, but rather by a system of percentages which vary with the number of feet. Thus, in a one-story building increasing by thousands from the unit of measurement—one thousand up to eight thousand—the charges increase 1 per cent for each additional thousand after the first charge of 2 per cent has been made for the first one thousand feet in excess of one thousand. Thus, for 8,000 square feet the charge would be 8 per cent.

Walls. Standards are given for the various types of walls—walls, independent or exterior walls, supporting or non-supporting walls, ledged and not ledged, walls braced with pilasters, and walls of poor construction. A standard differs according to the occupancy above grade. Naturally, a very light occupancy, as office, barber shop, etc., will permit of lighter walls than those of the ordinary hazard. The question of parapet and coping is taken into consideration. Also the question of a brick building being deficient in some respect, as by a frame extension or a frame side, while plate glass windows, if unusually large, are charged for. In rating from the frame basis, the frame wall is accepted as a standard and percentage credits are permitted for improved construction. The charges run 1 per cent for each inch of deficiency in the non-standard wall.

Roof. A standard roof has a metal, tile, slate, or approved composition with a charge of 20 per cent for a shingle or unapproved composition. Mansards are also especially charged for. In frame buildings the shingle or unapproved composition is accepted and the credit allowed where the roof is metal, tile, slate, or approved composition.

Ceilings. In brick buildings a charge of 20 per cent is made for wooden ceilings in each story, and 5 per cent for strawboard, paper, or canvas ceilings, each story. The charges are increased 50 per cent where the side walls are sheathed in like manner.

Skylights. In brick buildings, charges are made for openings through the roof not covered with standard skylights. Charges, 3 per cent for the largest opening, 40 square feet or less, increasing 1 per cent for each additional unit of like amount and 2 per cent for each additional skylight. In the case of photographers' skylights, 3 per cent charge is raised to 5.

Floor Openings. In brick buildings, the charges are made for such features but where protected with an automatic trap no charge is made. Credits are given when the openings through a floor of more than ordinary construction are protected in a superior manner. The technical term used in the schedule to describe the openings in a floorway is *retinue.*

In its treatment of floorway openings from a fire insurance standpoint, the schedule does perhaps one of the most consistent pieces of work in any schedule. It considers that the opening on which the great stress is always laid must not be deemed as a thing of itself and considered solely alone, but must be considered in connection with the construction of the floorway itself. Floorways are divided into four grades which are grouped as follows:

(1) Matched wooden flooring on joists of ordinary dimensions with lath and plaster, wood, or metal ceiling beneath.
(2) The same as (1), with the exception that the flooring is double.
(3) Deals with floorways which run as follows:
    (a) Where the floor is 3 inches thick and presumably adequate for the load.
    (b) Where the supports of the floorway, posts, beams, and girders are at least 6×6 inches and sufficiently strong for the load. Should they be of cast iron or steel, the protection must be at least 2 inches of fireproof material.
    (c) Where the finish is without any concealed places.
    (d) Where the partitions are non-burnable.
(4) Where the floorways are:
    (a) 3 inches splined plank covered with 1-inch flooring.
    (b) Where the floorway supports, posts, beams, and girders are at least 8 × 8 inches and sufficiently strong for their load. If metal to be protected, the beams must rest on ledges or if not then be self-releasing. The posts must be superimposed throughout with cast-iron caps, base plates, and pintles.

(c) Where the finish is without any concealed places.

(d) Where the partitions are non-burnable.

The floor openings, or retinues, are divided into four grades which may be roughly defined as follows:

(1) An opening with a standard trap or enclosure of matched flooring with enclosure door, if any, of same material and automatic in its closing.

(2) The same as (1), but of two thicknesses of matched boards.

(3) The opening protected with a metal-covered trap or door, as in the case of standard fire doors. Or an enclosure of plaster or cement on both sides of a metal lath attached to an iron frame or it may be tile or terra cotta, with a standard metal or metal-clad door and self-closing.

(4) Opening in brick shaft with standard fire doors. Presumably in place of the brick, either concrete or terra cotta would be acceptable.

The sign for plus indicates an addition and the sign for minus a subtraction in the floor-opening table. An illustration that has been used may make the subject clearer. Assume a three-story brick building with a basement. The floorways of matched wooden flooring, therefore, fall into group 1. An elevator runs from the basement to the second story. At the first floor it is protected by an automatic trap which grades 1 in the floor-opening group. The elevator opening through the second floorway is unprotected and, therefore, grades below 1. The schedule very consistently and rightly considers each floorway and its opening separately, and they are charged for, or credited for that matter, on that basis. The opening of each floor is graded by the opening in that floor which has the poorest protection. The charge, therefore, for the first floorway will be for a floor-opening grading below 1. Combined with the floorway which grades at 1—and this, by the table, calls for an addition of 5 per cent, that is, 5 per cent of the base rate. This method is followed for each floor opening. The sum totals of all the percentage additions for each floor will be the percentage of the base rate that is taken for floor openings. Floor openings should always be treated in the manner in which they are treated in this schedule. They should always have reference to the floorway itself. Floorways consisting of inch boards may be worn, and with cracks it is not such an important matter to have standard shafts. As a working rule, a shaft should be as good as the floor. All this from the fire insurance standpoint. With a coming of the fire prevention movement it is not impossible that we shall demand standard shafts in all classes of buildings, this being due to the consideration which is now given to the life hazard, as well as property hazard, which latter has hitherto governed in mercantile properties. It should be pointed out that if a floorway itself is weak, then the high-grade floor opening protection does not receive a maximum credit. It is considered, and undoubtedly rightly, that the floorway being weak will permit the fire to pass very rapidly from one floor to another. In common with other schedules the largest charge remains until all the floor openings have been protected. This fundamental idea in the charging for floor openings is based on the fact that one opening will permit water and smoke, although there may be no fire to pass from one floor to another. It is not necessary that there should be several openings to accomplish this. Therefore, until all are protected a maximum allowance can not be secured.

Where the partitions come in for consideration they are divided into the following classes:

(1) Below 1, ordinary wooden lath and plaster with the wooden doors.

(2) Plaster or cement on metal lathing with automatic closing doors of wood are 2 inches thick.

(3) Plaster or cement on metal lath or studding, or tile or brick with self-closing standard doors or the metal-clad doors. The schedule also provides that when a story of a building has light occupancy its floor openings, under certain cases, may be considered as in a class higher than they normally would be. Such a condition will usually be found in hallway construction such as in office buildings.

Partitions. In buildings of ordinary construction, the standard partition is either brick, tile, or plaster on both sides of metal, which latter is attached to iron supports. Or it may be some equally good fire-resisting material. Charges are made for departures from the standard.

Chimneys. In all buildings the standard for a chimney is brick built from the ground, although it permits a chimney to be ledged in the walls if the construction is of high grade and approved. All departures are charged for.

Outside Attachments. Outside attachments such as wooden cornices, awnings, roof houses, etc., are charged for. A building of ordinary construction is supposed to be free from these anomalies.

Superior Construction. Where a brick building has a superior construction, something beyond the standard, the schedule provides for a recognition of this feature or features, thus:

If the floors and their supports are in the highest class, 20 per cent is deducted, and for decreasing grades of superior construction, but yet above the ordinary 10 per cent or 5 per cent, is allowed.

Under the phrase "after charges," the schedule makes provision for those indisputably bad conditions in a risk which, in the Mercantile Schedule, are called faults of management.

Occupancy. The hazard of occupancy has been divided into three parts: (1) As originating combustion; (2) as a medium for fire, or as an aid to combustion when once it is started; (3) as an effect of either the fire, the smoke, or the water.

Combustibility. This is classified under five grades:

(1) Low-grade. Merchandise which does not in itself constitute a fuel for the spread of combustion, as hardware, leather, etc.

(2) Middling. Merchandise which burns moderately in itself, but may contain small quantities of a higher grade of combustibility. either through policy permits or common usage, as retail groceries, dry goods, or country-store stocks, etc.

(3) High. Merchandise which burns freely, making a very active fuel; store goods, millinery, etc.

(4) Quasi-Incendiary. Merchandise that burns with great intensity, is difficult to extinguish, not liable to spontaneous combustion, nor that can be ignited except it come in contact with fire, as matches, celluloid goods, saltpeter, etc. This grade also includes finely-divided particles such as shavings, but not substances which are divided into dust and having the explosion hazard.

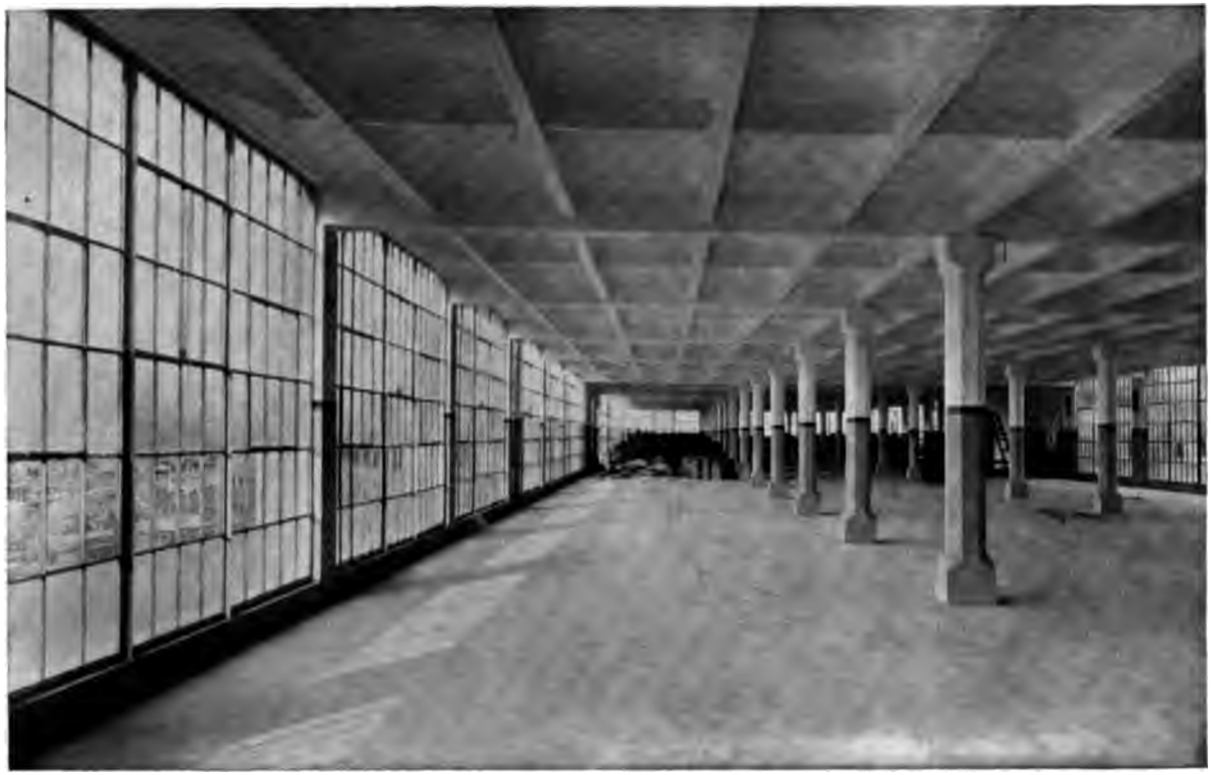
(5) Incendiary. This will include substances that burn as intensely as those in grade 4, and, moreover, give off an inflammable or explosive vapor at ordinary weather temperatures, as crude petroleum and all of its lighter products, ether, etc., and the waste material of planing mills, cotton gins, etc.

Moreover, there are two other divisions in addition to the five which have been enumerated. One is known as 3½ and represents a grade that can not be defined by any quality which it possesses, but is used principally to denote large open stocks which would be classed under grade 3, ordinarily, or for moderate quantities of stocks that properly come under grade 4. The next grade is 4½, which is made for the same purpose as grade 3½, and is principally for small industrial risks, or where the conditions described in grade 5 are reduced by blower systems. This grade is also used for large storage risks which otherwise might grade in 3 or 4.

Causes of Fires. Causes of fires are divided into two classes called the *inert* and the *active*. The inert represents those classes which may be considered without any active hazard as, for instance, a bank, a barber shop, offices, studios, sample rooms, etc. Active causes, or occupancies, are divided into three groups: Those which pertain to living conditions primarily; those which deal with assemblies or public building conditions; and those which deal with manufacturing conditions or, as they are termed, industrial. In addition to these three the hazard of traffic, which is that hazard caused by employes and customers in the regular transaction of business in mercantile properties, is taken into consideration. The living group include those classes of properties where residence is a principal factor, as apartment houses, boarding houses, hotels, club buildings, and lodging houses. The assembly group embraces all properties such as public halls, club rooms, lodging rooms, etc., where people may gather for any purpose. The industrial group consists "of all industrial activities found in mercantile buildings, either connected with stocks of merchandise or independent." The dangers or hazards of this group are divided into those which may be caused by the raw material and by heat-using devices.

The schedule furnishes a labor table which makes charges according to the number of hands employed, beginning with five hands or under, and increasing by units of five or ten up to the maximum.

Devices which use heat are of such an enormous range that a special table is furnished to enumerate and to classify them. Such devices, of course, may be the electric motors, gas engine, kerosene, natural gas, and gasolene engine. The table for such devices pro-



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vides for the hazards of one of these forms of machinery and then the charges are increased to double the charge for additional devices.

Furnaces are especially classified as hand or portable and fixed furnaces. Dry rooms also receive a special classification.

Damageability. The third factor in regard to fire loss is damageability. It is divided into four grades:

(1) Merchandise which is scarcely affected by the direct effects of fire. Heavy hardware, leather, and woolen goods, canned goods, etc.

(2) Merchandise which is but slightly affected, retail grocery, dry goods, etc.

(3) Merchandise that is very easily damaged, as musical instruments, books, butter, cheese, fruits, etc.

(4) Merchandise that is extremely susceptible to damage from a very slight cause or its resultant, sometimes termed and classified as "total loss risks" as, for instance, millinery, artificial flowers, florists' stock, live animals, etc.

Three other grades have been established as 1½, 2½, and 3½, to take care of conditions rather midway between 1 and 2, 2 and 3, 3 and 4. In regard to the matter of damageability, it is considered that it has no effect upon the building in which it is contained, that it should be regarded as a relative matter and it should measure the difference between the damage to the building and the damage to the contents. This line of reasoning has led to a departure from the percentage charge and a fixed charge is made for the item of damageability in computing the rate of the contents. To state it somewhat differently, up to a certain point the contents and building may be considered as subject to an equal amount of damage. Beyond that point the contents will be more subject to damage and there will be no relation between this damage and that of the building. Therefore, as there is no relation, it is an independent factor which must be dealt with, and this can be only by the addition of a fixed charge to the contents. The occupancy charges are arranged in alphabetical order as in the Universal and then the three sets of figures are furnished, that is, *first*, the combustibility; *second*, the media for fire, and *third*, the damageability. The first two, as previously explained, are percentage additions and the third is a charge of a certain amount for the damageability.

Protection and Exposure. The schedule is founded on the rating of an unexposed and unprotected building. In the early part of this work, under basis rates, reference has been made to the seven classes into which the Western Territory is divided according to the public protection. To facilitate the operation of the schedule the allowance for protection, that is, public, is taken from the base rate. The schedule furnishes tables for the different conditions. The schedule takes into consideration that under protection the damage to contents as compared with building may be greater than where there is no protection. In other words, the better the fire protection, the greater will be the loss on contents. Statistics show the loss on the contents in brick buildings not in excess of the loss in buildings where unprotected; also in the protected centers the loss on contents generally will greatly exceed that of the building. All these and other factors are taken into consideration in making the allowances for public protection, and differences, of course, are made between properties of brick and frame construction.

Private protection deals with the usual items coming under that head: Standard pipe and hose, fire escapes, automatic fire alarm, chemical extinguishers, fire pails, watchman with approved clock, heat from an outside source, or no heat and approved whitewash or fireproof paint. Percentage allowances are granted for all of these factors, the sum total of the allowances amounting to 46 per cent.

Exposure. The origin of the schedule which is now being considered was due, as shown in the quotation from Mr. Dean's letter, to a desire to work out an exposure formula for certain conditions. He stated that the extent to which buildings radiate, absorb and transmit hazard depends upon the fire protection of the city or town, upon the construction of exposing and exposed walls, and upon the distance between the exposing and exposed walls. Naturally, the suppression of fire depends upon public fire protection. The construction of the walls of the exposing and exposed buildings are taken into consideration. Decimal ratios furnish the amount of exposure presumed to be absorbed by the exposed building. Clear space would naturally reduce this amount and of course the distance must be considered. Provision is made for abnormal exposures such as an exceedingly small one or an exceedingly large one, while other factors that are given attention consist of the falling-wall exposure, wall-damage exposure, buildings of an equal height, exposures not opposite each other, fire-stop walls in frame rows, while finally, elective exposures represent those cases where there is a choice of methods in measuring the exposure charge. It is presumed that that method which gives the highest charge is the proper charge to make, it being deemed a fundamental principle that if the charges are at least approximately correct, the rate represents the highest hazard and is the one which must be taken into consideration. An example showing a rate on this schedule, which example is taken from a paper by H. M. Hess, is given herewith. It represents one building in a row of seven buildings. References to the schedule, page, and section have been omitted from the example as they are not necessary to the purposes.

Building. Basis rate, 5-story brick .55 plus .07		$0.62
Area 65 ft.×95 ft. equals 6,175 sq. ft. on 6 floors including basement	26%	
Supporting walls, right, exterior, average thickness 16 inches, which is deficient 4 inches from standard of 18 inches, charge	2%	
Left, party, average thickness 19 inches which is standard, no charge		
Not ledged, charge	6%	
Parapets, right, unexposed, no charge		
Left, adjoining building 1 story higher with opening 18 inches above roof, no charge		
Total deficiency charge	34%	
Floorway openings.		
All floorways are semi-mill construction and therefore grade at "C"; stairway and dumb waiter in brick shaft through roof with standard automatic fire doors on openings and, therefore, grading "d"; 1 elevator from basement to 5th story with openings protected by standard tin-clad automatic traps, and, therefore, grading as "c". Credit for floorways ("C") with retinue "c", 5×2%	10%	

Net deficiency charge	24%	
Occupancy, candy factory and bakery 25% plus 40%	65%	
65 hands, additional labor	42%	
6 open motors 20% plus 5/5 of 20%	40%	
Furnaces, see furnace table: 3 ovens, coke fuel, 35% plus 2/5 of 35%, equals 49%; 5 candy kettles, gas fuel, 55% plus 4/5 of 55% equals 99%, reduced ½ for gas fuel equals 50%; total charge, 49% plus 50% equals 99%; maximum charge, 35%×2	70%	
Total	241%	1.49
Occupied building rate (gross)		$2.11
Credits—		
Structural features. All floorways grade as "C"	10%	.21
		$1.90
Protective features. Inside standpipe and hose.	5%	.09
Individual rate		$1.81

SOME GENERAL PROBLEMS

The rate of insurance includes all charges that may be made against the company in connection with its business. In life insurance it is customary to compute the premium or rate at a net amount and then to load this for expenses. In fire insurance, on the other hand, the expenses and all other items are included in the rate as computed. In other words, the rate when first computed is all inclusive.

In the ratings thus far considered, except in the Analytic Schedule, the non-fireproof and the fireproof building have received special consideration. In the Analytic Schedule, as pointed out, a different basis rate is used where the risk is a frame than where it is of ordinary construction. No fully-developed schedule for rating fireproof buildings has yet been brought forth under the Analytic System. In due time, undoubtedly, this will be done.

The Universal Schedule makes provision for the frame building having a well-developed schedule. It has not been used to any extent, probably due as much as anything to the fact that it was deemed a marked advance when the schedule was first put into use to bring the buildings of ordinary and fireproof construction under schedule rating.

The frame building on general principles is worth the same rate as the contents. The rate on a manufacturing schedule for a frame risk may be computed in precisely the same manner as though the building were of non-fireproof construction, minor charges would be omitted but there would be a specific charge added for the character of the construction, that is, frame. This would, in a plant of any size, amount to probably half a dollar. The frame risk is all too prominent still in the United States, but it will pass away and in due course be superseded by non-fireproof, and then fireproof structures. The greater part of the building construction in the United States numerically is still of the frame class and it is probable that this condition will continue for many years to come.

The building of mill construction, which would generally be considered as coming mid-way between the non-fireproof and the fireproof, receives credit by a percentage reduction from the final rate as computed for a non-fireproof building. The full type, standard mill construction would receive a very large credit. It is the practice to grant some slight concession where, although the building may not be fireproof, there may be specific parts, as the floors, which are far beyond the ordinary construction. The old type of mill-constructed building with the large timbers is probably not being erected today to any large extent. The size of timbers necessary are not easily procurable. It is being replaced by the reinforced concrete building, or by a modest-priced fireproof building with ironwork fully protected. The record of the buildings of mill construction in fires has been excellent, especially when under the protection of sprinklers.

There are some few cases in rating where the susceptibility to damage to the stock is so great that more than one rate may be made for the contents. An example of this kind is a florist's stock which would be ruined by a very slight degree of heat. It is good practice in rating to make a distinction between the stock, such as the flowers, etc., as against the furniture and fixtures which are not so susceptible to damage. The same is true concerning live stock of any kind, as birds in a store, horses in a stable, or cattle in a barn. All animals are easily affected by fire and smoke and may be considered in the very highly susceptible class.

Fire insurance, being designed to indemnify the insured for the loss which he has sustained on account of the fire, in addition to covering the loss which may occur to the building and all the contents, has gone beyond that and provides indemnity against certain other losses which may be occasioned by a fire, although they do not have a tangible physical form, such as the stock of a store or a building. Among these may be considered:

Rent Insurance. The ordinary lease is so drawn that if the building be destroyed by fire to a certain point the lease is broken and the income ceases or the terms of the tenant may be such that even a slight fire will terminate the lease. Then the owner will suffer a loss of rents occasioned directly by the fire. Rent insurance is a form of loss to which fire insurance peculiarly applies, and policies were written quite early in the history of the business. The rates for rent are generally based on a certain percentage of the rate of the building and are generally subject to the rules governing insurance on the building.

Use and Occupancy. Use and occupancy insurance refer to that form of insurance which covers a loss that may be sustained because one does not have a normal use and occupancy of the building. In a sense, it has a wider range than rent insurance since every tenant of a building may have a legitimate desire to conduct his business at the location, and to conduct it without interruption. A fire is an interruption and may occasion a severe loss. Hence, this form of insurance is provided for and here again the rates are generally based on the contents, since the relation of this form of insurance bears a closer relation to the condition of the contents than it does to the building, as in the case of rent insurance.

Lease Insurance. Lease insurance is only a form of rent insurance and is subject, usually, to the same rules and laws.

Commissions and Profits. Commissions and profits represent another form of insurance which runs, in a measure, with the two preceding, although it is not a case of a physical factor such as a building and contents. A large stock of goods may have been sold, the commission payable on delivery. Before they can be delivered they are destroyed by fire and the profit or commission has been lost. Fire insurance provides an indemnity against this form of loss. The rate is generally the same as the rate on contents.

Pawnbrokers. Pawnbrokers have a peculiar form of liability to loss represented by the right and the interest which may be due under pledges which they hold. The interest on pledges, where the time of the loan has not expired, represents an accumulating value to the pawnbroker; the interest is steadily going on. It is a general custom to insure this right and interest and the rate will range much lower than the general contents and yet not be as low as the building. Another example of practically the same thing is what is known as the warehouseman's accrued charges. A warehouseman having taken goods on storage has an increasing interest in those goods because of the storage money which he expects to receive. A destruction of the property by fire before the goods are taken out of storage might occasion the entire loss of his expected receipts for storage. The insurance of these accrued charges covers that liability to loss.

Blanket Policies. Blanket policies are generally governed by a rate of insurance which is the highest rate applying to any one piece of property under the blanket policy. The wide cover which a blanket policy may have, covering an entire street railway property, for instance, thus making a loss under the policy for a fire that occurs anywhere along the lines, entitles the companies to a somewhat larger return than for a risk which is more minute than specific in description and location. There is but one other way to avoid the charging of the highest rate and that is to have the value submitted for each piece of property which it is desired to cover under the blanket and to make an average rate based on the submitted values, and the rates applying to each specific piece of property.

Builder's Risk. This is a matter which affects the rate. All of the policies of fire insurance permit ordinary mechanics to be employed about the building without causing an increase in the rate of insurance. Ordinarily mechanical work may be done without any limit as to time, under the general rules governing fire insurance. The standard policies and probably even those which are not standard give this privilege for not exceeding fifteen days. This also means that within these fifteen days anything may be done to the property which may be desired, that is, extra alterations and repairs may be made. If the work may not be finished in fifteen days then special permission must be sought and for this a charge is made, varying according to the construction of the building, being less as the building is of better construction.

Cold Storage Risks. Cold storage risks, depending as they do on the steady supply of artificial cold air for their success, and this artificial cold air being created by mechanical means, may be seriously affected by a fire. A fire which would not destroy any of the goods might so cripple the cold-air plant as to practically destroy all of the property stored. If the companies did not protect themselves they would all too frequently find that they were assuming a risk not contemplated. It is an established practice to attach to policies covering this class of risks a special clause limiting the liability which may be occasioned by a breaking down of the cold-storage plant or else charging a rate two or three times as large as the ordinary rate.

Coinsurance. This is not permissible in a great many states in the United States; hence, rates must be made without that useful instrument. In states where it is permitted the rates are based generally on an insurance of 80 per cent of the value of the property. Should the insured desire to carry 100 per cent, or full coinsurance, then an additional allowance may be made.

Loss by Ordinance. Local ordinances affect the loss by fire. For example, a building of frame construction may be standing within the fire limits. The frame building is not immediately ordered to be taken down, but when it is destroyed by fire or any other means and a new building is to be erected on that spot, that new building must conform to the ordinance covering the district in which the building is located. If the ordinance calls for a fireproof building, then a fireproof must be erected. It is clear that a building of frame construction would not cost anything like the sum which a fireproof building would cost. Nevertheless, the owner is forbidden to erect anything but a fireproof building. This is a loss which calls for a larger expenditure of money in addition to that occasioned by fire. This contingent liability, as it is frequently termed, is covered in much the same manner as consequential loss is, by a very substantial increase in the rates; that is, if the company assumes the liability of replacing the building with one called for by the ordinances in case the old one is destroyed.

Term Policies. The term policy, as an earlier definition has stated, is a policy written for more than one year. The most common forms of the term policy are those covering a building where the rate is either two or two-and-one-half times the annual rate for three years. As a rule, the term policies apply to any form of structure such as buildings, piers, etc., and may apply to the furniture and fixtures, or household furniture, wherever it is situated. In all the rates which have been quoted in this work and wherever rates are quoted, the annual rate is the one which is in mind. It is evident that if the annual rate on a building is $1.00 and it may be written for three years at twice the annual rate, this is an average rate of 66⅔ cents.

In the beginning of fire insurance, and for a century or more for that matter, it probably was a very useful advertising medium to make this substantial reduction where a building was written for more than one year. It must have appealed to the insured very much to know that if he wrote for more than the shortest period that he would in effect save this amount of money. It is very doubtful whether any such reason exists for that practice today. The inducement, of course, is not necessary because all properties are insured. The allowance also is probably too large. It has recently been set forth by an underwriter that the discount for term policies should be reduced to a fractional part of what they are now. However that may be, the point that is sought to be emphasized is this: viz, that when the annual rate is quoted on a building it is well to remember that buildings are written generally for a term and that the annual rate may be subject to a deduction of nearly 20 per cent, where the property is written for three years, if not a larger deduction. As methods of rating grow more and more exact the term policy will probably pass away or the inducement offered will be so slight as to practically effect its banishment. A more just method would be to compute the rate as closely as possible and then make an allowance equal to the rate of interest on the reserve. This is about all that should be done.

Exclusion of Certain Property. The rate as a rule covers all of the property in the risk. It takes into consideration that a building has foundations, brick walls, paper for the interior finish and various other items. Some parts are highly susceptible to damage; others are not, as the foundations. This fact of the susceptibility of different parts is also known to the insured, who very frequently seeks to take advantage thereof by excluding from the policy those parts which he thinks are the least liable to loss; unless this exclusion has been taken into consideration in computing the rate, it is evident that it is the same thing as reducing the rates of insurance on the more hazardous parts. The underwriter has estimated that the loss even if a fire starts in the property may be a slight one owing to the large amount of solid and rugged construction. But this consideration may be entirely defeated if the insured, having secured a low rate over all, then is permitted to exclude all the best parts of the risk. For example, the foundations when they are below the level of the ground are generally excluded, but no other part of the rated property.

Improvements. Improvements to building represent counters, shelving, and things of like nature which the lessee may have to put into the building. All these it is permissible for him to insure as improvements to the building and the rate which is applied follows the building rate.

Contents of Fireproof Safes and Vaults. This class covers cases where special care is taken of property and on account of this extra care and protection a large consideration is granted in the rate. A jeweler's stock consisting principally of precious stones where the property is in a fireproof building and in a fireproof vault receives extremely low rates varying according to the article, in some cases, from 7½ cents for diamonds unset to 25 cents for watches and watch movements. Where the property is located in a building of non-fireproof construction, but still contained in a fireproof safe or vault, low rates for the class of property enumerated in the jeweler's stock will be granted, but these rates generally do and always should bear some relation to the rate of the property in which they are located, and vary according as the risk is a good or a bad one. It is customary in some parts of the country to divide the rate of the building of non-fireproof construction by 5, and to this to add specific charges, such as the flat charges in a fireproof building, for the precious stones and jewelry and watches or watch movements.

In addition to these valuable articles which form a very common type of risk, there may be anything contained within fireproof safes. It is customary for general merchandise which is contained in a fireproof safe or vault, to receive a percentage discount from the rate for merchandise outside of safes. This discount will run about 33⅓ per cent.

Short Rate. This is a type of rate the opposite of a term rate. The latter represents a period longer than a year; a short rate represents a period less than a year. The tables given on pages 132 and 133 illustrate some of the different short rates which are in force in different parts of the country. They differ only to a slight extent.

Clauses and Warranties. Clauses and warranties are vital factors in the computation of the rate of insurance. Certain reductions which are made in the rate are made only on the basis of a clause stipulating that certain things shall be done; for instance, automatic fire alarms, special building signals and the sprinkler system, all carry with them a warranty that the insured shall use *due diligence* in keeping these equipments in good order. If it were not for the warranty as set forth in the clause, the insured might well ignore the fact that he received a substantial reduction in his rate and proceed to dispense with the useful device after he had secured the rate reduction.

The clauses referred to above fall under the standard class of clauses. Another group more local, more individual in their character, are warranties which are guaranteed to meet certain peculiar conditions in connection with a risk. One of the most common of these, and it illustrates the series, is where there is a boiler in a building and it is used only for heating the property, although it may be capable of generating any amount of pressure beyond that used. The rate will contain a charge for this boiler. The insured desiring to have the charge removed states his willingness to accept the warranty that the boiler will not be used or if used the steam will be limited to not exceeding ten or fifteen pounds pressure. As the last type of warranty is individual it is evident that it might be multiplied to any extent according to the peculiar conditions in any given property.

SHORT RATE TABLE AND RULES GOVERNING SAME, CITY OF NEW YORK

All insurances for a term less than a year shall be charged according to the scale for periods less than one year, but insurance may be once renewed for the ratio of the premium required for the term for which the original policy or last renewal was made, provided the renewal is made within ten days from the expiration of the policy, and, provided the last preceding term was one year, or a term charged for according to the scale of insurance for less than a year.

All insurance for a term less than one month shall be charged for the portion of a month, according to the short rate scale; but in no case shall this clause be so construed as to conflict with the following clause relating to cancellations, viz:

A policy may be canceled at any time at the request of the assured, in which case the company shall retain the customary short rate for the term the policy has been in force; but in all cases, except that of policies on contents of listed storage stores written for a month or more, fractional parts of a month shall be charged the full month's premium; no return to be made on a policy written for a period less than one month.

The intention of the above is ruled to be as follows, viz: Policies on contents of listed storage stores can be canceled for less than one month at short rates for the fractional part of a month; but if both written and carried for more than one month, fractional parts of a month can not be allowed for in cancellation.

	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
ANNUAL RATE.....	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	110	125	150	175	200	225	250	275	300	325	350	375	400	450	500
1 Day..........	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	10
2 Days..........	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20
3 Days..........	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	6	6	8	9	10	11	11	13	15	16	18	19	20	23	25
4 Days..........	2	2	2	2	3	3	3	4	4	4	5	5	5	5	6	6	7	8	9	11	12	14	15	17	18	20	21	23	24	27	30
5 Days..........	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	8	10	12	13	15	17	18	20	22	23	25	27	30	33
10 Days..........	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	13	15	18	20	23	25	28	30	33	35	38	40	45	50
15 Days..........	3	4	5	5	6	7	7	8	9	9	10	11	11	12	13	13	15	17	20	23	27	30	33	37	40	43	47	50	53	60	67
20 Days..........	4	5	6	7	8	8	9	10	11	12	13	13	14	15	16	17	18	21	25	29	33	38	42	46	50	54	58	63	67	75	83
1 Month..........	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	25	30	35	40	45	50	55	60	65	70	75	80	90	100
2 Months........	8	9	11	12	14	15	17	18	20	21	23	24	26	27	29	30	33	38	45	53	60	68	75	83	90	98	105	113	120	135	150
3 Months........	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	44	50	60	70	80	90	100	110	120	130	140	150	160	180	200
4 Months........	13	15	18	20	23	25	28	30	33	35	38	40	43	45	48	50	55	63	75	88	100	113	125	138	150	163	175	188	200	225	250
5 Months........	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	66	75	90	105	122	135	150	165	180	195	210	225	240	270	300
6 Months........	18	21	25	28	32	35	39	42	46	49	53	56	60	63	67	70	77	88	105	123	140	158	175	193	210	228	245	263	280	315	350
7 Months........	19	23	26	30	34	38	41	45	49	53	56	60	64	68	71	75	83	94	113	131	150	169	188	206	225	244	263	281	300	338	375
8 Months........	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	100	120	140	160	180	200	220	240	260	280	300	320	360	400
9 Months........	22	26	30	34	38	43	47	51	55	60	64	68	72	77	81	85	94	106	128	149	170	191	213	234	255	276	298	319	340	383	425
10 Months........	23	27	32	36	41	45	50	54	59	63	68	72	77	81	86	90	99	113	135	158	180	203	225	248	270	293	315	338	360	405	450
11 Months........	24	29	33	38	43	48	52	57	62	67	71	76	81	86	90	95	105	119	143	166	190	214	238	261	285	309	333	356	380	428	475

STANDARD SHORT RATE SCALE

FOR

Computing Premiums for Terms Less than One Year

AS ADOPTED BY THE "WESTERN UNION"

RULE

Take the percentage indicated in scale opposite the number of days risk is to run, on the premium for one year at given rate, and the result will be the premium earned in case of cancellation, or to be charged in case of short risks.

1 Day........	2 per cent. annual prem.	55 Days........	29 per ct. annual prem.
2 Days.......	4 " "	60 "	30 " "
3 "	5 " "	65 "	33 " "
4 "	6 " "	70 "	36 " "
5 "	7 " "	75 "	37 " "
6 "	8 " "	80 "	38 " "
7 "	9 " "	85 "	39 " "
8 "	9 " "	90 " or 3 mo .	40 " "
9 "	10 " "	105 "	45 " "
10 "	10 " "	120 " or 4 mo..	50 " "
11 "	11 " "	135 "	55 " "
12 "	12 " "	150 " or 5 mo..	60 " "
13 "	13 " "	165 "	65 " "
14 "	13 " "	180 " or 6 mo..	70 " "
15 "	14 " "	195 "	73 " "
16 "	14 " "	210 " or 7 mo..	75 " "
17 "	15 " "	225 "	78 " "
18 "	16 " "	240 " or 8 mo..	80 " "
19 "	16 " "	255 "	83 " "
20 "	17 " "	270 " or 9 mo..	85 " "
25 "	19 " "	285 "	88 " "
30 "	20 " "	300 " or 10 mo	90 " "
35 "	23 " "	315 "	93 "
40 "	26 " "	330 " or 11 mo	95 " "
45 "	27 " "	360 " or 12 mo	100 " "
50 "	28 " "		

SCALE FOR COMPUTING EARNED PREMIUM

ON

Term Policies Canceled before Expiration

THREE YEARS	FIVE YEARS
3 mo. or less......20 per ct. term prem.	5 mo. or less......20 per ct. term prem.
over 3, not ex. 6....30 " "	over 5, not ov. 10....30 " "
6 mo., " 9....40 " "	10 mo. " 15....40 " "
9 " " 12....50 " "	15 " " 20....50 " "
12 " " 15....60 " "	20 " " 25....60 " "
15 " " 18....70 " "	25 " " 30....70 " "
18 " " 21....75 " "	30 " " 35....75 " "
21 " " 24....80 " "	35 " " 40....80 " "
24 " " 27....85 " "	40 " " 45....85 " "
27 " " 30....90 " "	45 " " 50....90 " "
30 " " 33....95 " "	50 " " 55....95 " "
33 " ....100 " "	55 " ....100 " "

SOME FINAL CONSIDERATIONS

The average rate of insurance over the whole country has been given in the first part of this subject. The table annually prepared by the National Board of Fire Underwriters, showing the fire risks written, the fire premiums received, losses paid, together with various averages including the average rate for each state in the United States for the year 1910, the last year of full record available, is worthy of study and is herewith presented for that purpose, Table VIII.

The District of Columbia, with an average rate of 53 cents, has the lowest average rate of any specific governmental division for which the statistics are collected. Next was the state of Delaware, with an average rate of 79 cents and then the state of New York with an average rate of 80 cents. From these low figures the amount rises through various sums apparently reaching the maximum in the territory of Alaska, where it was $2.63.

If anyone should ask what is the primary benefit that has been derived from schedule rating or the modern system of determining the fire insurance rate in general, probably the best reply and the one nearest the truth would be that the fire insurance tax is today being collected, under the present system of rating, in the most equitable manner that it has ever been collected in the history of the business. When it is realized that the fire insurance loss affects hundreds of different forms of property, and each form of property calls for special consideration, according to the place where it is situated, the type of building in which it may be located, if it be personal property, and its own susceptibility to damage, multiply this by the thousand and one circumstances that it is possible to have, and it should be readily seen that to scientifically determine a fire insurance rate is something which the work of two centuries has not furnished sufficient time to accomplish. That immense gains are being made in that direction there is no doubt, but much remains to be done. The actuary in determining the rate of insurance in life insurance has the important bedrock factor to base his data on, that every risk will eventually be a total loss if the policy be carried to conclusion. No other form of insurance has any such anchorage to hold to. As a matter of fact, in fire insurance but three or four properties in one hundred losses will be total losses. The

TABLE VIII

This Table exhibits by States the Average Rate of Premium and Loss Ratios of Joint Stock Fire Insurance Companies for 1910.

The same information for a period of thirty years, 1880 to 1909, inclusive, is from "Fir Insurance by States."

STATES	Fire Risks Written 1910	Fire Premiums Received 1910	Fire Losses Paid 1910	Rate of Premium to each $100 of Risks, 1910	Average Rate of Premium to each $100 of Risks, 1880-1909 inclusive, 30 years	Ratio of Losses Paid to $100 of Premiums 1910	Ratio of Losses Paid to $100 of Premiums, 1880-1909 inclusive, 30 years	Ratio of Losses to $100 Risks Written. 1910.	Ratio of Losses to $100 Risks 1880-1909 inclusive, 30 years
Alabama	$197,993,669	$3,501,023	$1,639,823	$1.76	$1.60	$46.8	$54.5	$.83	$.87
Alaska T.	4,742,786	124,866	101,939	2.63	*a*2.51	81.7	*a*17.9	.22	*a*.45
Arizona	30,681,259	713,502	472,305	2.32	2.51	66.2	57.3	1.54	1.43
Arkansas	112,575,286	2,321,339	1,177,398	2.06	1.89	50.7	58.5	1.05	1.10
California	957,599,716	15,439,268	5,651,776	1.61	1.63	36.6	105.4	.59	1.72
Colorado	225,230,046	3,316,727	1,234,357	1.47	1.58	37.3	43.9	.55	.69
Connecticut	410,759,739	4,093,857	2,043,332	.99	.96	49.9	45.2	.50	.43
Delaware	57,884,584	457,382	161,317	.79	.82	35.4	52.2	.28	.43
Dist. of Col.	116,229,548	610,280	233,582	.53	.61	38.2	33.9	.20	.21
Florida	131,310,230	2,686,748	1,066,361	2.04	2.07	39.7	70.7	.81	1.46
Georgia	373,916,571	5,014,931	2,455,615	1.35	1.32	48.7	54.1	.66	.71
Idaho	54,737,832	1,118,652	968,760	2.02	2.43	86.6	53.0	1.77	1.28
Illinois	1,995,653,768	23,214,810	11,209,152	1.16	1.19	48.3	48.6	.56	.58
Indiana	652,860,401	6,874,489	3,281,489	1.06	1.18	47.8	52.9	.50	[illegible]
Iowa	489,339,075	6,546,642	2,942,842	1.34	1.49	45.0	44.9	.60	.67
Kansas	333,065,189	3,781,774	2,247,180	1.14	1.28	59.5	51.9	.68	.67
Kentucky	348,293,363	4,779,902	2,065,456	1.37	1.33	43.3	58.3	.59	.77
Louisiana	288,442,195	4,497,520	2,221,717	1.56	1.26	49.5	49.5	.77	.63
Maine	181,011,221	2,715,539	1,279,864	1.50	1.42	47.2	61.4	.71	.87
Maryland	393,264,315	3,905,240	1,837,360	.99	.84	47.0	96.7	.47	.81
Massach'setts	1,292,871,842	12,922,105	6,855,495	1.00	.99	53.1	57.6	.53	.57
Michigan	862,674,375	8,008,577	4,332,691	.93	1.34	54.1	51.4	.50	.71
Minnesota	570,354,023	7,467,120	5,585,060	1.31	1.41	74.8	54.9	.98	.78
Mississippi	156,344,142	2,835,178	1,908,098	1.81	1.88	67.5	59.1	1.22	1.11
Missouri	805,728,225	8,116,262	4,953,126	1.01	1.16	61.2	57.7	.62	.67
Montana	90,532,354	1,756,081	548,560	1.94	2.24	31.2	38.5	.61	.86
Nebraska	285,675,447	3,633,054	2,152,602	1.27	1.42	59.3	43.2	.75	.61
Nevada	18,816,750	415,166	162,141	2.20	2.57	39.1	39.7	.86	1.01
New Hamp.	106,443,583	1,192,877	521,602	1.12	1.23	43.7	53.3	.49	.66
New Jersey	1,114,478,873	10,189,580	4,744,832	.92	.86	46.5	49.5	.43	.43
New Mex.	33,847,019	599,067	398,573	1.77	1.89	66.5	51.4	1.18	.97
New York	5,648,143,372	45,354,051	20,897,952	.80	.67	46.2	54.8	.37	.37
N. Carolina	257,375,954	3,296,096	1,340,962	1.28	1.38	40.8	53.6	.52	.74
N. Dakota	99,979,919	1,897,350	1,181,494	1.90	*b*1.92	62.3	*b*60.8	1.18	*b*1.16
Ohio	1,135,140,160	12,408,211	5,013,049	1.09	1.12	40.3	53.9	.44	.61
Oklahoma	274,849,727	3,361,926	1,836,828	1.22	*c*1.50	54.7	*c*49.2	.67	*c*.74
Oregon	211,834,000	3,317,760	*1,125,688	1.56	2.00	33.9	43.1	.53	.86
Pennsylvania	1,873,631,649	20,727,192	9,341,884	1.11	1.11	45.1	51.0	.41	.57
Rhode Island	171,717,875	1,578,786	906,292	.92	.94	57.5	50.9	.53	.47
S. Carolina	181,122,663	2,940,654	1,267,620	1.62	1.29	43.1	55.2	.70	.71
S. Dakota	115,993,327	1,781,685	814,225	1.54	*a*1.63	45.7	*a*43.3	.70	*a*.70
Tennessee	375,095,698	5,326,212	2,389,201	1.42	1.51	44.9	64.8	.64	.98
Texas	643,890,705	8,799,156	5,980,959	1.36	1.58	68.1	59.5	.93	.95
Utah	90,916,818	1,168,948	382,052	1.29	1.65	32.7	39.3	.42	.65
Vermont	89,894,164	1,362,769	916,980	1.52	1.38	67.3	61.6	1.02	.85
Virginia	362,441,186	*4,799,817	†2,409,293	1.32	1.41	50.3	54.5	.66	.77
Washington	291,348,265	5,198,256	2,883,696	1.78	2.07	55.6	48.6	.99	1.01
W. Virginia	150,316,609	2,404,587	1,287,263	1.60	1.44	53.5	49.6	.86	.71
Wisconsin	763,913,541	8,574,984	3,876,068	1.12	1.39	45.2	50.7	.51	.72
Wyoming	21,472,679	424,582	106,203	1.97	2.00	25.1	34.6	.49	.67

***a*—27 years; *b*—20 years; *c*—28 years; *Gross; †Incurred.**

others of the hundred vary from a small loss of 1 and 2 per cent up to 90 per cent. In San Francisco the salvage—which means the property left after a fire—was between 7 and 8 per cent throughout, where a large number of risks were taken into consideration. In the majority of cases, of course, the loss was total, but the salvage averaged about as given. A broker was once asked whether he considered his business a science or a profession. His reply was that he considered it neither, but that he rather regarded it as a fine art. Probably fire insurance rating borders a little more on the art than science today, for, with the exception of the high-grade sprinkler risks where the data is extremely complete, there is not a sufficient body of collected data to enable one to speak with such absolute assurance that a fire tomorrow may not upset his utterance.

Science implies fixed laws and principles which are undeviating in their workings and which, under like conditions, will always produce like results. Mathematics is the most exact science, probably, that we have. It follows absolutely exact processes and under like conditions produces like results. Two plus two will always produce four. If there was a like foundation to build on in fire insurance rating most of the difficulties in the business would vanish. A single illustration will show the point. The conflagration in Chicago was started by the overturning of a kerosene lantern by the kick of a cow. Now if every time a cow kicked a lantern and overturned it, there was a conflagration of like size with the Chicago one, we should be able to lay down a law that two plus two, in such cases, make four. But how many lanterns have been kicked over without even starting an ordinary fire, let alone a large one or a conflagration. Two plus two do not always make four in the rating problem because not all is known about the "two" of fire insurance mathematics. If it is not a science, is it an art? And if so, why? An art has certain fixed canons but it also has a large field of endeavor or combination which apparently does not obey any fixed law and where the artist may roam at will. If it were not so, all works of art of the same order would be identical. The artist, however, does not quite furnish the illustration which will best stand comparison with rating in fire insurance. The field of medicine is a bit nearer. Here certain areas of knowledge have been brought under the domain of law, rather their laws have been discovered, but each day is showing

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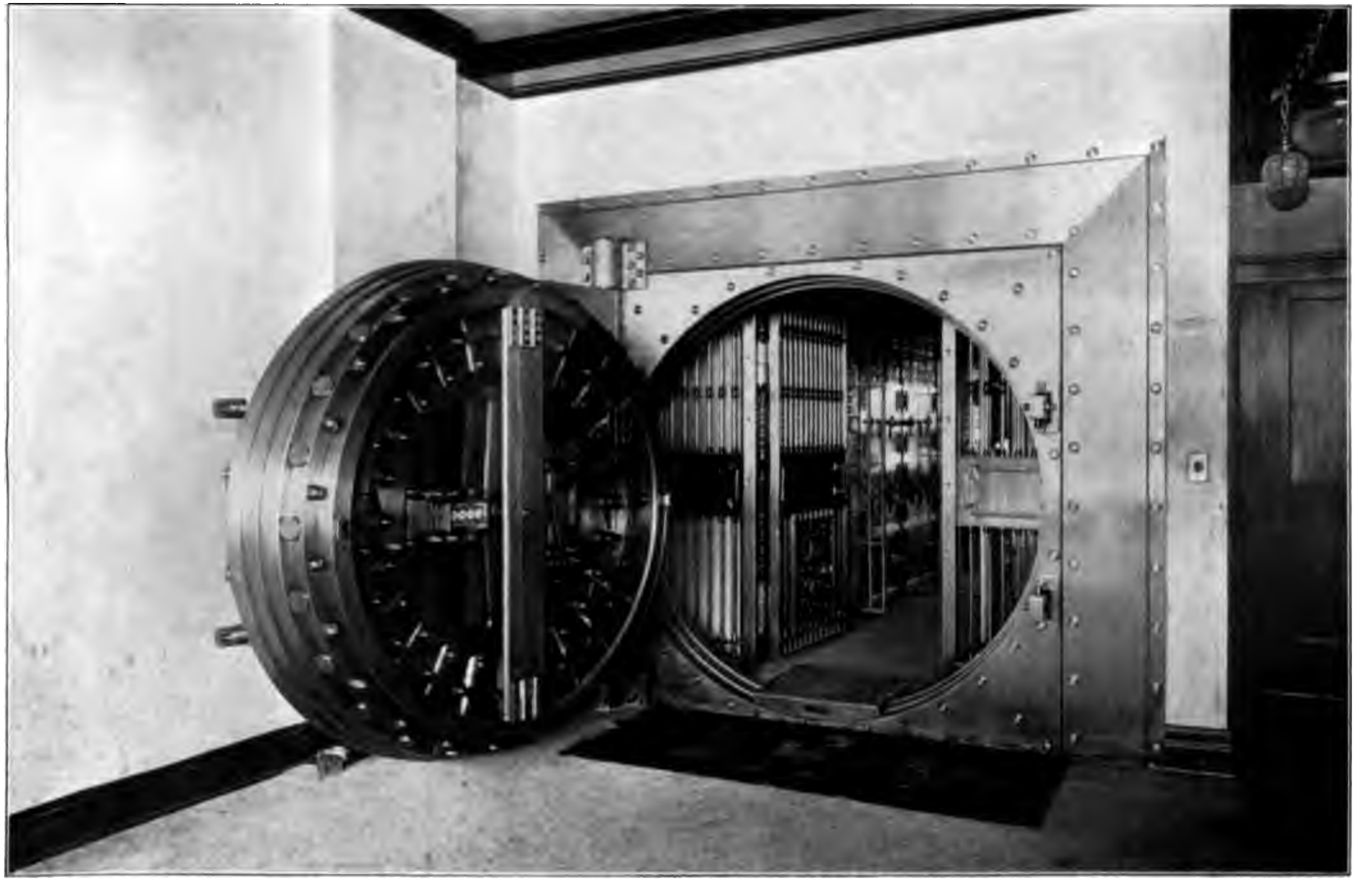

FIREPROOF VAULT

new stretches of territory as yet unmapped and where the laws are unknown.

Then, too, the attitude of the public toward medicine differs from that toward the other professions, not to say a great many other things. A layman will seldom attempt to draw a will or draft a deed, but will consult a lawyer for this purpose. The layman will not argue that two plus two do not make four but submit to the mathematician. In the field of medicine, however, the laity roam at will. To possess a cold is to have offered to you a remedy by almost every person you meet. This applies not only to colds but most other diseases. The interesting point is not the thing itself but the attitude of the laity toward this subject. Why is it that the laymen use medicine in this light and not law and many of the other sciences? Is it not due to the simple fact that medicine is as yet an art and not a science? The lawyer can, with a fair degree of accuracy, draft a will that will stand or a deed that will hold, but the laity have learned that the physician cannot promise a cure and he himself knows that two and two do not always make four.

The application to be made of all this in rating is namely, that the attitude of the laity toward rate making in fire insurance is much the same as that of the laity toward medicine. Whatever else the layman may not know about in fire insurance it is a rare one who is not positive that he knows what the rate should be on his property.

Possibly this attitude is produced by the fact that the average fire insurance policy is not called upon to pay a loss. In a record of four hundred thousand policies, thirty in one thousand was the number that was subject to a loss. A somewhat higher average has been furnished by another underwriter who placed it at about six in one hundred or sixty to one thousand, and then added that if it proved to be only five in one hundred you made money, but if it proved to be seven, you lost. It is true that the policy of insurance is necessary to the conduct of modern commercial business. Credit is based upon it. The business man knows this but it is rather a negative than a positive thing. A loss under the fire policy is positive and the insured has a different feeling toward his fire insurance premium after a loss than he does before.

Whatever the reason, this attitude of the insured toward the business—and the crux of the business is rate making—is one of the reasons why the work must always of necessity be more or less educational in its nature. There must be steadily preached the gospel of good building laws, fire prevention, fire protection, coinsurance, and whatever else may affect the fire loss adversely. Under the modern system of schedule rating the necessity for this is perhaps greater than under the ancient system of a few classes and flat rates. This is due to the fact that the insured under a system which so minutely analyzes his risk is led to feel that it is an individual matter and the mutuality of fire insurance is forgotten. His risk is analyzed; he is furnished with a copy of the rating and as he analyzes it, item by item, feels that for each and every factor for which a charge is made he has been duly assessed. This very fact of computing the tax by a series of items enforces this upon him and under the diction that the insured determines his own rate it is driven still more forcibly into his consciousness. It is only within a limited degree that the insured can determine his own rate except where the conditions permit of high-grade sprinkling and a financial independence or size which gives control of the property. The principle of mutuality always existed and always must exist in the business of insurance. It is, after all, merely a system in every branch of collecting a small sum from a large number in order that the few may not lose a large sum. Each contributes his small sum because he may be the one who needs the large sum. "To tax and please never belong to government," said Edmund Burke. The business of fire insurance is laying a tax in the eyes of the insured at least. To lay this tax and please at the same time is a problem calling for the same ability that makes a success of the greatest government undertakings.

REVIEW QUESTIONS

REVIEW QUESTIONS

ON THE SUBJECT OF

CHEMISTRY OF COMBUSTION

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1. What do you understand by chemical change? Give an example (not mentioned in the text).

2. What is an atom? Molecule? Element?

3. What is the difference between a mechanical mixture and a chemical union? Give illustration.

4. What causes chemical action?

5. What do you understand by nascent state?

6. What is the effect of pressure and temperature on a gas?

7. Name the most important chemical and physical properties of oxygen.

8. Are the terms *combustible* and *supporter of combustion* interchangeable?

9. What is heat? Temperature?

10. How is a flame produced? Why are some flames more luminous than others?

11. Describe the structure of an ordinary match flame, and tell all you can about it.

12. How would you determine the approximate flashing point of ordinary sawdust?

13. What is the difference between the fire test or burning point and the ignition point of a liquid combustible?

14. Why is the expression *spontaneous ignition point* incorrect?

15. Under what practical conditions is linseed oil liable to heat spontaneously?

16. In general, how should oil fires be extinguished?

17. Why is water generally used to extinguish fires?

18. What do you understand by a detonator?

19. Why are oxygen carriers hazardous?

20. In what respects is gasoline more hazardous than alcohol? Than heavy mineral oil?

21. What is meant by explosive range?

22. Under what conditions does a dust explosion occur?

23. In considering the liability of a flammable liquid to be accidentally ignited why is it important to take into consideration its flashing point and the zone of average temperature?

24. Is the expression *flammable* or *inflammable liquid*, literally speaking, correct?

25. What would happen if gunpowder were ignited in a vacuum?

REVIEW QUESTIONS

ON THE SUBJECT OF

UNDERWRITERS' REQUIREMENTS

PART I

1. Explain briefly the electrical causes of fires.

2. State in general terms the means to be taken in every installation to guard against such fires being started.

3. As affecting the fire hazard, describe the essential differences between

   (a) constant-current systems and constant-potential systems;

   (b) low-voltage and high-voltage circuits.

4. What is the National Electrical Code?

5. Into what main subdivisions are its rules divided?

6. Describe the chief desirable characteristics of a generating station with regard to the fire hazard.

7. In judging the safety of an installation of electric motors, what are the chief items to be considered?

8. Describe a motor-starting rheostat.

9. What is an autostarter?

10. What is the object of a continuous duty resistance?

11. What are transformers?

12. State the advantages of the use of transformers with regard to the fire hazard.

13. What precautions must be observed in installing transformers?

14. Outline the standard practice for outside wiring.

15. What is electrolysis?

16. What precautions are to be taken in connection with the installation of high-tension lines?

17. What is a ground on an electric circuit?

18. Where is a ground permissible or desirable?

19. State the purpose of fuses.

20. How should fuses be chosen for any given circuit?

21. Why are cartridge and plug fuses preferable to link fuses for general use?

22. What are the advantages of electric heating devices?

23. Why is the electric flatiron more hazardous than other heaters?

24. What is there to examine in the inspection of an installation of electric fixtures?

REVIEW QUESTIONS

ON THE SUBJECT OF

UNDERWRITERS' REQUIREMENTS

PART II

1. What is open-work wiring?

2. What is the essential principle of conduit work?

3. What are the advantages and disadvantages of concealed work?

4. Outline the chief things to be considered in electric installations when subject to a continual dampness.

5. When should wood molding never be used?

6. What are the chief points to be observed in wiring a theater?

7. How should the footlights be installed?

8. With a voltmeter having a resistance of 24,000 ohms and a battery of 26 volts, it was found that the voltmeter read 6 volts when connected in series with the battery and the wiring of a house. What was the insulation resistance of the wiring?

9. Why are rubber-covered wires used almost exclusively in all inside wiring?

10. What is a "slow-burning" wire?

11. Describe a "weatherproof" wire.

12. Give the dimensions of a cartridge fuse for a circuit of 110 volts, 20 amperes.

13. In what way do telephone wires in a home affect the fire hazard and what fire precautions should be taken?

14. What is a snap switch and what is its distinguishing feature?

15. Describe a characteristic conduit installation for an apartment.

16. State the chief advantages, from the point of view of the fire hazard, of the use of electricity as compared with gas in residence lighting.

17. Why are sign flashers hazardous?

18. What are the wiring requirements for stage auditoriums?

19. State the wiring requirements for moving-picture theaters.

20. How thick is the rubber installation of No. 4 B&S wire?

21. What is a circuit breaker?

22. Describe a panel board.

REVIEW QUESTIONS

ON THE SUBJECT OF

ELEMENTS OF FIRE INSURANCE

1. Define *insurer, policy, rate, premium.*

2. Give a brief history of the development of Fire Insurance.

3. Give four fundamental principles of Fire Insurance. Can a house on a fine residential street be insured for more money than one costing the same money located in a poor section but having the same water protection? Why?

4. Discuss how Fire Insurance benefits commercial enterprises.

5. How is the *rate* on any definite risk obtained by the companies?

6. What is a *binder* policy? Is it valid?

7. Describe the characteristics of a Joint-Stock Fire Insurance Company.

8. Show how Mutual Companies differ from Joint-Stock Companies. Which of these two is the more important?

9. What is the *pro-rata* principle? What are the duties of the attorney-in-fact in Inter-Insurers Companies?

10. Give the general characteristics of Inter-Insurers Companies.

11. Describe the operation of Lloyds, London.

12. How is a department or general agency of a Joint-Stock Company organized?

13. Give the duties of a *local agent,* and his relations with the home office.

14. What are the duties of the examiners?

15. What are the advantageous and disadvantageous features of the Mutual Companies?

16. In what ways have Manufacturers' Mutuals influenced the general ideas of Fire Insurance?

17. What are the functions of the National Board of Fire Underwriters, and how does it perform these functions?

18. Outline the duties of an *inspector*.

19. What are the qualifications of a good underwriter and what are his duties?

20. Explain the functions of an *insurance broker*. Should he know anything about insurance matters?

REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE RATING

PART I

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1. Define "rate of insurance," a "minimum rate," a "specific rate," an "average rate."

2. On what value were rates first based; how long did this last?

3. What discount was allowed where properties were insured for more than the shortest period?

4. What rates were charged for contents when they were first insured?

5. What was the group system of rating?

6. Give an example of a special hazard; and what was the earliest tariff applied to this type of risk?

7. Did the methods in the United States differ from those in Great Britain in the beginning of fire insurance?

8. What were classes of hazards and how many were there in a representative case?

9. Mention some different businesses or properties that fell into each of the four following divisions: (a) not hazardous; (b) hazardous; (c) extra hazardous; (d) special.

10. When did the schedule system begin in the United States?

11. What is the classification system and what is its purpose? Does the average rate of insurance throughout the United States show much fluctuation from year to year?

12. Give a brief sketch of rating organizations.

13. How do you define a "schedule"? What object is sought by the schedule in laying a tax of fire insurance?

14. What is the most common type of risk in the United States or in any country, for that matter? What is the next most common type?

15. What is an internal exposure charge?

16. Mention eight different schedules which have been developed for specific classes of property.

17. State the reasons for having specific schedules for specific classes of risks.

18. What two types of schedules are used for rating the largest number of properties?

19. How many points are taken into consideration in rating a church, as shown by the schedule?

20. Why does a schedule for piers take into consideration but a very few items?

21. What new principle is brought out in the theater schedule different from those which have been previously considered?

22. On the theater schedule warranties number 1 and 2 call for certain equipments. Why should the allowance for this equipment be subject to a warranty?

23. What principle of the base-rate schedule is illustrated by base rate as computed for a printer?

24. Why should every hazard in a non-fireproof building affect the rate of all the tenants and the same not be true in a fireproof building?

REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE RATING

PART II

1. Why is the Universal Schedule for written properties desirable?

2. State briefly the seven fundamental principles of the Universal Mercantile Schedule.

3. Into what seven divisions does the schedule itself properly fall?

4. What is a *key rate?* What is a *standard city?* What is a *standard building?*

5. What points in determining a key rate impress you as of the most moment?

6. In the non-fireproof schedule how many points may be considered in the following: (a) In the first series of charges; (b) in the first series of deductions; (c) the second series of deductions; (d) under faults of management?

7. What does each point in the schedule represent; is it the outgrowth of practice or is it theory?

8. What should a wall of a building accomplish?

9. Why are concealed spaces considered as defects?

10. What principle is represented by the stop charge under area?

11. What are the objections to wood cornices, cupolas, etc.?

12. What purpose is sought by the deductions under items 119 to 124 inclusive?

13. Why is an automatic alarm more of a protection than the special building signal?

14. What other purpose may a watchman serve than the mere protecting of the property in case of fire?

15. The allowance for self-releasing beams is only made in the rate of the building. Why should it not apply to its contents?

16. Mention some half dozen items that come under faults of management.

17. What purpose is served by tarpaulins, covered cases, and skids?

18. What is ignibility? Give an illustration.

19. What is susceptibility? Give an illustration.

20. What was the old method of charging for an exposure?

21. What is represented by the modern exposure table such as the Universal?

22. In the example of rating which is given on the non-fireproof schedule, how many items were charges made for, and what deduction could have been made in the property by possible improvements, the cost of which was not prohibitive?

23. What was the first method of making allowances for fireproof buildings? What is the method of rating fireproof apartment houses today?

24. What is the purpose of the charge under item 297 A?

25. The allowance for coinsurance on a fireproof building is very large. What reason do you give for this?

26. Why is it necessary in certain risks to have a series of occupancy charges, as in the case of wholesale grocers, coffee establishments, department stores?

27. When sprinklers were first introduced what method was adopted for making allowance in the rate of insurance for this device?

28. What change took place in the methods in 1905?

29. What does the grading schedule of sprinkler properties aim to accomplish?

30. What is the restricted sprinkler schedule and how would you say it differs from the other schedules that you have studied?

REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE RATING

PART III

---

1. What three principles are considered as basic in the Dean Schedule?

2. Explain the matter of "relativity" as emphasized by the Dean Schedule.

3. What forms the base rate of the Dean Schedule?

4. In its treatment of floor openings, does the Dean Schedule differ from the Universal or some of the other schedules? If so, discuss the differences.

5. Into what parts has the hazard of occupancy been divided?

6. Into what parts has *combustibility* been divided?

7. Into what two classes are the causes of fires divided?

8. What groups are there in damageability?

9. The Universal Schedule takes as a starting point a standard building in the standard city. What does the Dean Schedule take? Discuss.

10. Have frame buildings been rated on any schedule up to the present time? If not, why not?

11. What method is adopted to make an allowance for mill-constructed buildings?

12. Why should more than one rate be made sometimes for the contents of a store, as a florist or bird store?

13. Mention some classes of insurance which have grown out of the practice of protecting property by fire insurance.

14. What is peculiar to the rate of insurance for pawnbrokers?

15. What is a *blanket policy?*

16. What must be guarded against in fixing the rate of insurance on cold storage risks and in losses by city ordinances?

17. What is a *term policy?*

18. Why does the owner want to exclude certain property?

19. What is a *short rate?*

20. What degree of responsibility is sought to be enforced in connection with sprinklers and warranties of like nature?

21. What, if any, benefit has been derived from the modern system of schedule rating?

22. Can rating claim to be scientific? Give reason for your answer.

23. Explain how the principle of mutuality must always exist in the business of insurance.

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